

A Job-Search Model Of Migration
Between Metropolitan Areas

By

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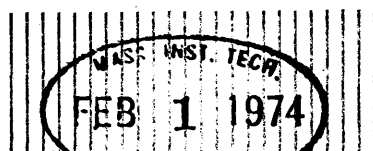
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Abstract

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This thesis is submitted to the Department of Urban Studies and Planning and Department of Economics in partial fulfillment of the requirements for the degree Doctor of Philosophy.

Based on data on past migration and survey research on actual migrants, a model of migration based on the economics of information is developed. The properties of this migration function are analyzed and found to be consistent with microeconomic theory. Estimates of a particular form of the migration function using data from both the U.S. and U.K. provide parameters that are significant and that have the expected sign.

About The Author

Presently an assistant professor of economics at the George Washington University in Washington, D.C., Tony Yezer was born in that city in 1944. He was an undergraduate at Dartmouth College where he fulfilled the requirements for a degree in chemistry before switching to a major field in economics. A relatively weak background in economics was supplemented during a year at the London School of Economics made possible by a N.C.A.A. Scholar-Athlete award. Shortly after coming to the Massachusetts Institute of Technology he switched into the joint program in economics and urban studies and planning which resulted in this thesis.

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INTRODUCTION

Streams of human migration have had overwhelming sociological, cultural, and economic consequences. Nowhere is this more true than in the United States which is today peopled by the offspring of immigrants and continues to experience high rates of internal migration among its culturally and economically diverse sub-regions. For example, the movements of Negroes out of the rural South and Puerto Ricans from the Commonwealth of Puerto Rico to the middle atlantic states imply profound and probably unique social and cultural changes on the part of the migrants.

There are also important effects arising from the movement of a relatively homogeneous population within a system of urban areas. Such migration involves little cultural change but its potential economic impact in countries like the United States, where one in eight families changes its county of residence each year, is great. This thesis attempts to model the movement of homogeneous populations as opposed to unique population movements discussed earlier. Migration is treated as a purely economic process of labor market adjustment. The analysis developed here should not be applied directly to unique flows of heterogeneous population groups where important cultural change accompanies migration. However, just as the

perfectly competitive ideal provides a framework for interpreting oligopoly, the abstract and idealized approach adopted here for movement of homogeneous populations should provide a basis for understanding unique population movements. Indeed there is some evidence that historical migrations between diverse regions or from rural to urban areas have exhibited some empirical regularities which may be due to common underlying economic factors.¹

Migration between metropolitan areas is an important determinant of regional and urban growth patterns. Understanding and predicting population flows is vital to rational planning for urban development. In some metropolitan areas, such as Washington and Los Angeles, net in-migration has been more important than natural increase in accounting for the growth of population. In such areas planning programs which relied on population projections based on natural increase alone would result in inadequate provision of public facilities. Conversely, the majority of counties in the United States experienced a fall in population between 1960 and 1970 due to out-migration in excess of natural increase. Here excessive investment in public facilities would result from planning based on projected natural increase.

Recently migration has become important in another context. Persistent differences in wages and unemployment

¹This issue is discussed in Chapter I:1.

rates among areas have led to speculation that present levels and/or patterns of migration are not efficiently moving labor services from areas of surplus to those with current shortages. In this context migration is seen as an investment in human capital which has a rate of return that is sufficiently high to indicate that market processes are not allocating sufficient funds to migration. Thus increasing investment in migration is viewed as a short-run strategy to shift the Phillips curve and as a long-run answer to problems of lagging regions. Resolution of the debate over optimal migration must wait upon the formulation of positive models of the migration process which relate to the body of microeconomic theory. The models developed here represent an attempt at such a formulation.

Chapters I and II of this thesis review empirical data on migration flows and existing analytical models of migration processes. In Chapter III an analytic theory of migration is developed based on a job-search model of the labor market. Problems of simultaneous equation bias and inconsistent aggregation inherent in any attempt to estimate migration equations are reviewed in Chapter IV. Chapter V contains estimates of aggregate migration equations for the United States and the United Kingdom. A summary of results and conclusions follows in Chapter VI.

Chapter I

EMPIRICAL RESEARCH ON MIGRATION

The limited nature of migration data sources has long inhibited empirical work on migration processes. The three sections of this chapter relate roughly to the three traditional sources of data on migrants; net migration flows based on census data on changes in population; gross migration flows obtained from census questions concerning place of residence one or five years earlier; and surveys of migrants designed to determine reasons for mobility. Various descriptive statistics computed from these data suggest a variety of persistent empirical regularities that appear to characterize migrants and migration processes. Any microeconomic theory of migration should be consistent with the more well-established empirical generalizations.

I:1) Classical "Laws" Of Migration

The primary data sources available to demographers since the sixteenth and seventeenth centuries were bills of mortality and certificates of baptism recorded in larger cities. From these data and population totals practitioners of "Political Arithmetic," as demography was then named, were able to construct estimates of net migration. They found very strong patterns of population flows from rural areas and

small towns to great cities. Until the nineteenth century most large European cities had an excess of deaths over births accompanied by substantial population increases.¹ Improved sanitation and medical practice lowered death rates in cities. By the mid-nineteenth century, natural increase was a more important factor in London's population growth than it had been in the seventeenth century, although rural immigration flows were still substantial. Net immigration was about 6000 per year in 1650 and 11,000 annually in 1870 but the population of London had increased by a factor of ten during this period.²

In the late nineteenth century the results mentioned above were supplemented by British census reports on population by area of residence, and place of birth. E. G. Ravenstein developed six empirical generalizations based on the historical pattern of migration to London and data from the censuses of 1871 and 1881.³

1) most migration covers short distances,

2) migration proceeds in stages with one person filling the place vacated by another who had moved earlier;

3) each main current of migration produces a compensating

¹ Weber, Adna Ferrin, The Growth Of Cities In The Nineteenth Century, (Ithaca, N.Y.; Cornell University Press), 1899, pg. 235,

² Grant, John, Natural And Political Observations On The Bills Of Mortality, (Fourth Impression, Oxford, England), 1665, pp. 81-84

³ Ravenstein, E. G., "The Laws Of Migration," Journal of the Royal Statistical Society, Vol. 48, No. 2, (June, 1885) pp. 167-227.

countercurrent of migrants;

4) the longest distance movers generally go to large cities;

5) town and country dwellers are generally less migratory than rural residents;

6) and, females are more migratory than males.

Observations of a similar character had already been made by Georg von Mayr, chief of the Bavarian Bureau of Statistics.¹

An additional generalization arising in von Mayr's 1871 paper was that the percentage of native born population decreases with city size except for rural communities under 500 where it varies directly with size. This result is consistent with Ravenstein's fifth law.

No thorough attempt to test these classical "laws" of migration against recent migration flows will be made here; but recent investigations have reached similar conclusions. The first two "laws" are basically complimentary and have been combined in current literature in the notion of "chain" migration.² Rural-urban migration in the United States typically proceeds in stages from farm to rural community to small town, etc. Over a period of time migrants appear to be moving into vacancies created at successive links of a chain leading to

¹ von Mayr, George, "Die bayrische Bevolkerung nach der Geburtigkeit," in Heft XXXII der Bertrage zur Statistik des Konigreichs Bayerns, (Munchen, Deutchland), 1876.

² See, for example: Lurie, Melvin, and Elton Rayack, "Radial Differences In Migration And Job Search: A Case Study," Southern Economic Journal, Vol. XXIII, No. 1, (July, 1966) pp.

the largest cities. There is also some evidence that these migration "chains" represent very specific linkages between particular origins and destinations, not suggested on the basis of transportation cost or geographic proximity.¹

The third "law" of migration, that flows in one direction produce or are associated with counterflows, has been most difficult to rationalize in terms of economic theory. In effect it appears that individuals reverse their location decision in a systematic fashion. Since Ravenstein virtually all investigators have noted the high ratio of gross to net migration, on which the third "law" is based. This can be illustrated with data from the United States. The past three decades have witnessed large net outflows of southern negroes to other areas of the country. Estimates of the incentive to migrate based on the relative social and economic condition of negroes in different areas in the United States have found large returns to this outmigration.² Victor Fuchs found that the net differential in average hourly earnings, adjusted for differences in age, education, and city size, in earnings between the south and non-south was: 7% for white males, 9% for white females, and 35% for both non-white males and

¹ For example, a large fraction of negro migrants to Norristown, Pa. came from one county in South Carolina due to recruiting efforts in 1914-1918 by the railroads. Reported in: Goldstein, Sidney, Patterns Of Mobility 1910-1950: The Norristown Study, (Philadelphia, Pa.: University of Pennsylvania Press) 1958, pg. 38

² The return to south-north migration is reported to be \$800 per year in: Wertheimer, Richard F., "The Monetary Rewards Of Migration In The U.S.," (Washington, D.C.: Urban Institute), 1970, p. 40.

females.¹ As Table I:1:1 below indicates, the gross flows which characterize non-white migration between southern and northern census divisions are seldom less than twice and usually more than thrice as large as net flows. Thus even in the presence of very large incentives to migration in one direction, south to north, there are large flows in the opposite direction.

Furthur examination shows that the flow of non-whites to the south consists largely of individuals born in the south who previously migrated to the north. Column 3 of Table I:1:1 indicates that return migrants were in all cases far more important in migration flows than their numbers would indicate, being over-represented in north to south migration flows by a factor of 6 or 7 to as much as a factor of 40. Considering migration flows net of migrants returning to their division of birth, in column 5 of Table I:1:1, gives much more decisive ratios of gross to net migration. Thus the high ratio of gross to net migration for non-white population movements is due largely to return migration by individuals born in the south who moved north earlier. This gives some additional insight into Ravenstein's third "law" but it is far from providing an understanding of the causes of the countercurrents that accompany initial migration flows.

¹Fuchs, Victor R., "Differentials In Hourly Earnings By Region And City Size, 1959," Occasional Paper #101, (New York:National Bureau Of Economic Research), 1967.

TABLE I:1:1

Relative Propensity To Migrate Between Census
Divisions Of The U.S. By Place Of Birth Of Migrant
(Non-White Population Only)

Place of Birth	Origin Population (Col. 1)	Gross Migrants (Col.2)	Migrants As Fraction Of Origin Pop. (Col. 3)	Ratio of Gross/ Net Migration (Col.4)	(Col.5)
Male Migrants From South Atlantic To Middle Atlantic					
South Atlantic	2,217,894	41,351	0.93	3.3	1.4
Middle Atlantic	26,784	3,371	7.0		
Male Migrants From Middle Atlantic To South Atlantic					
Middle Atlantic	507,776	6,475	0.81		
South Atlantic	409,204	9,835	1.6		
Female Migrants From South Atlantic To Middle Atlantic					
South Atlantic	2,423,736	56,133	0.96	1.6	1.2
Middle Atlantic	24,706	3,611	6.0		
Female Migrants From South Atlantic To Middle Atlantic					
Middle Atlantic	552,524	4,549	0.64		
South Atlantic	506,755	11,022	1.7		
Male Migrants From East South Central To Middle Atlantic					
East South Central	1025063	4,854	0.87	2.1	1.4
Middle Atlantic	2,233	309	25.6		
Male Migrants From Middle Atlantic To East South Central					
Middle Atlantic	507,776	801	0.90		
East South Central	57,500	859	8.0		
Female Migrants From East South Central To Middle Atlantic					
East South Central	1139907	7,383	0.91	1.3	1.1
Middle Atlantic	1,512	311	40.0		
Female Migrants From Middle Atlantic To East South Central					
Middle Atlantic	552,524	348	0.48		
East South Central	64,233	1,002	12.0		

TABLE I:1:1
(continued)

Descriptions Of Census Divisions

Middle Atlantic Census Division - Maryland, District of Columbia, Pennsylvania, Delaware, New Jersey, and New York.

South Atlantic Census Division - Virginia, North Carolina, South Carolina, Georgia, and Florida.

East South Central Census Division - Alabama, Mississippi, Kentucky, and Tennessee

Notes on the Calculations in the Table

Column 3, migrants as a fraction of population at the origin, is equal to the ratio of gross migrants, column 2, and origin population, column 1. The ratio of gross to net migration in column 4 is equal to the difference in gross migrants in each direction divided by the sum of gross migrants in column 2. The ratio of gross to net migration in column 5 is calculated in similar manner with return migrants eliminated from the calculation.

¹U.S. Bureau of the Census, U.S. Census of Population: 1960 Subject Reports, Mobility for States and Economic Areas, Final Report PC(2)-2B, (Washington, D.C.: U.S. Government Printing Office), 1963.

The last three classic "laws" of migration are fairly innocuous but they are essentially consistent with data on recent migration flows in the United States. The robustness of these classic observations on migration, now about to enter their second century, is quite remarkable. There has been a consistent tendency to ignore much of this early work on migration in spite of its continued validity. Perhaps this is due to the failure of recent migration models to account for behavior characteristic of classic migration studies. The job-search model of migration presented here accounts for most of the classic results that still apply today.

I:2) Migration Flows In The United States

In her 1938 summary of research on migration, Dorothy Swain Thomas disparaged the state of inquiry in the United States as "trivial and inept."¹ Her criticism was not only based on the lack of specific data on population flows. The problem with past research centered on the lack of imaginative analytical approaches to the available data.

Kuznets and Miller analyzed changes in the composition of population in different states and regions that occurred

¹ Thomas, Dorothy S., Research Memorandum On Migration Differentials, (New York: Social Science Research Council), 1938, pg. 160.

between 1870 and 1950.¹ They found a continuous reduction in the divergence among the proportions of state populations comprising different age, sex, and race groups. In her analysis of state work forces, Miller noted a convergence of indicators such as labor force participation rates and the proportion of employment in each of eight industrial categories. The sum of the divergence of deviations of individual states from the national average for most labor force indicators decreased steadily from 1890 to 1950.² This indicates an equilibrating effect of net migration which is consistent with neoclassical models of economic growth in the absence of barriers to factor mobility.

Analysis of indirect indicators of the effect of geographic labor mobility has also revealed fundamental long-run leveling processes. Most significant has been the convergence of income per capita and wages per manhour. Easterlin's index of the average deviation of income per capita among states fell almost fifty percent between 1927-32 and 1944-48, and remained constant from then until his last computation for 1953-55.³ Subsequent work on changes in relative wages among regions has shown similar convergence followed by stability,

¹Kuznets, Simon, Ann Rather Miller, and Richard A. Easterlin, Population Redistribution And Economic Growth, (Philadelphia: American Philosophical Society), 1960.

²Kuznets, Simon, et. al., Ibid, pp. 7-101.

³Easterlin, Richard A., "Interregional Differences In Per Capita Income, 1840-1950," Vol. 24, National Bureau Of Economic Research, Conference on Research In Income And Wealth, (1960).

particularly of the north-south money wage ratio, in the post World War II period.¹ Of course both supply and demand phenomena produce movements in relative wages in different regions. The recent stability of relative wages and per capita income may be due to a long-run equilibrium of some sort or result from compensating labor supply and demand effects that are temporarily in balance. However there is little doubt that migration has contributed to the stability of relative wages among regions in recent years. The lowest income states have experienced net outflows of migrants and the highest income states have been gaining population through migration.² Thus, in spite of the rise of countercurrents or reverse migration, the overall effect of migration flows on labor markets has been to shift population in a manner consistent with the elimination of income differentials among regions.

The inclusion of a question on migration in the 1940 U.S. Census of Population made possible the analysis of characteristics of migrants. Differential migration studies compared the proportion of a population subgroup that migrated with the average ratio of migrants to population.

Crosstabulations of the population, such as those found

¹Kuznets, Simon, et. al., op. cit., pg. 171.

²A review of the relative wage literature appears in: Galaway, L., "The North-South Wage Differential," Review of Economics And Statistics, XLV, (1963), pp. 264-272.

in Table I:2:1 show that for adults the proportion of migrants varies directly with education and inversely with age. Tables have been made for a host of detailed population subgroups.¹

TABLE I:2:1

U.S. Intercounty Migration Rates Per 100 Males By Age, Education, And Occupation For 1966 - 1967

Education Or Occupation	Age		
	25-34	35-44	45-64
Years of Schooling Completed			
College (1 year or more)	15.7	8.8	4.5
High School (4 years)	9.6	5.7	3.5
High School (1 to 3 years)	9.9	5.4	2.8
Elementary (8 grades or less)	9.1	5.6	3.1
Occupational Status			
White Collar	12.8	6.6	3.2
Manual	9.1	4.9	2.3
Service	7.7	3.2	1.8
Farmers And Farm Manager	3.3	2.2	0.4
Farm Laborers And Foremen	12.5	12.8	9.3

From: U.S. Department of Commerce, Bureau of the Census, Current Population Reports: Population Characteristics, Series P-20, No. 171, (Washington, D.C.: U.S. Government Printing Office), 1968.

The high mobility of farm workers confirms the 5th classic law. Bogue and Hagood concluded that "internal migration is selective of persons with particular combinations of traits" and that "selectivity in migration with respect to a particular characteristic can vary both in pattern and intensity among different places."² Thus the relative size of differential

¹See, for example: Fein, Rashi, "Educational Patterns In Southern Migration," Southern Economic Journal, (1965), pp. 106-124.

²Bogue, Donald and Margret Hagood, Differential Migration In The Corn And Cotton Belts, (Ann Arbor: U. of Michigan), 1953, pg. 125.

migration flows among areas depend on the characteristics of the areas as well as those of the population subgroups involved. For example, in the case of migrants to Miami Beach, Florida, there might be a positive association between age and relative migrant flows. This is inconsistent with the relative migration rates observed for the entire nation and reflects particular characteristics of the area.

I:3) Survey Research On Migration

The most detailed information on migrants comes from large surveys of the population. Thus far the masses of survey data and related results have been largely ignored in more theoretical research. Two sorts of information have resulted from surveys. First it has been possible to compare the characteristics of migrants with those of the population in general. Secondly unique insights into the rationale for migration and the migration decision itself are available in terms of the perceptions of the migrants themselves.

A commonly stated objective of surveys of migrants has been the determination of the importance of "economic considerations" in general and employment opportunities specifically in motivating migration between areas. Unfortunately many surveys have interpreted "economic" reasons for moving very narrowly. Thus an "economic rationale" for moving typically

includes only responses that indicate a move was designed to: take a job already offered; look for work; or to complete a job transfer. Housing problems, health problems, general cost of living, and "community considerations" are inevitably classified as non-economic reasons for moving. No attempt is made to determine if housing or health facilities were completely unavailable at the origin of the move or whether they were merely more expensive than at the destination. This approach indicates complete money illusion on the part of the survey researchers. The possibility that this also reflects money illusion on the part of migrants will be discussed later.

In spite of the narrow definitions used, a majority of all respondents in all surveys reported that they moved primarily for "economic reasons."¹ Job transfers or taking a new job dominated the responses of those who reported that they moved for economic reasons. In general only about twenty percent of those who reported that they moved for economic reasons moved in order to look for a job that had not been prearranged. The full results of four surveys that attempted to deduce the reasons for moving are given in Tables I:3:2 through I:3:5 below. Results of similar questions asked intra-county migrants are also presented to indicate

¹This generalization is based on the four studies mentioned in the tables below.

TABLE I:3:2

Reasons For Moving - 1946 Bureau Of Labor Statistics

Reason For Moving	All Adults 18-64 Percent Giving Reason As Primary	Males 18-64 Only Percent Giving Reason As Primary
1. To Take A Job	40.2	49.9
2. Too Look For Work	11.7	13.2
3. Housing Problems	14.7	15.0
4. Change In Marital Status	10.1	3.5
5. Health	2.9	2.7
6. Other Reasons	20.4	15.7

From: Department of Labor, Bureau of Labor Statistics, 1946
Current Population Survey, quotation from: Shryock,
Henry S., Population Mobility Within The United States
(University of Chicago:Community And Family Study
Center), 1964.

TABLE I:3:3

Reasons For Moving - 1963 Bureau Of Labor Statistics

Reason For Moving	Males 18-64 Only Percent Giving Reason As Primary
1. To Take A Job	29.5
2. To Look For Work	11.9
3. Job Transfer	8.1
4. Marriage And Family	14.6
5. Other	35.3

From: Department of Labor, Bureau of Labor Statistics,
Geographic Mobility And Employment Status, Special
Labor Force Report, (Washington, D.C.:U.S. Government
Printing Office), May, 1964.

TABLE I:3:4

Reasons For Moving - Lansing And Mueller Survey

Reasons For Moving	Family Heads, Percent Who Moved In Last 5 Years (Interstate Moves)
1. No Reason Given	5
2. Non-Economic Reasons	23
3. Partly Economic Reasons	14
4. Only Economic Reasons Given	58
a. Transfer, Reassignment of Head	15.5
b. Unemployment, Desire For More Steadier Work, Enter Workforce	12.4
c. Higher Rate Of Pay, Better Advancement Opportunities	24.2
d. Other Economic Reasons	9.9

From: Lansing, John, and Eva Mueller, The Geographic Mobility Of Labor, (Ann Arbor, Michigan: University of Michigan Press), 1967, pg. 38.

TABLE I:3:5

Reasons For Moving - 1966 Bureau Of The Census Survey

Reasons For Moving	Percent Of Males 18-64 Who Moved In Last Year:	
	Intercounty	Intracounty
1. Easier Commuting	9	9
2. To Take A Job	24	4
3. Job Transfer	8	1
4. To Look For Work	9	2
Total Job-Related Reasons	50	16
5. Enter Or Leave Armed Forces	10	1
6. Better Housing	10	56
7. Forced Move (Housing)	1	6
8. Health Reasons	4	2
9. Join Or Move With Family	11	8
10. Change In Marital Status	4	11

From: U.S. Department of Commerce, Bureau of the Census, Current Population Reports: Population Characteristics, Series P-20, No. 154, (August, 1966), pg. 4.

the diminished importance of job-related reasons for moving as the distance covered decreases.

In Table I:3:4, the percentages of workers moving for economic reasons only and for higher rates of pay specifically may not seem impressive at 58 and 24 percent of all primary reasons respectively. But these figures are considerably higher than the corresponding percentages reported for voluntary separations and for all accessions in the literature surveyed by Herbert Parnes.¹ In most cases less than 20% of the workers responding, both for voluntary separations and all accessions, reported that their action was based on absolute or relative wages in the job left or recently accepted. For voluntary separations Parnes found that the intrinsic nature of the job and human relations factors were most often cited as reasons for changing jobs. Employees who were newly hired reported other economic factors and the intrinsic nature of the job were most important in their decisions. There is some lack of comparability between the questions typically asked in survey research on job mobility in general and those associated with the migration decision that generated the results in Tables I:3:2 - I:3:5. However, the relative importance of general economic considerations and even specific wage considerations in the migration decision appears

¹ Parnes, Herbert, Research On Labor Mobility and Labor Allocation, (New York: Social Science Research Council) Bulletin #65, 1954, pg. 75.

to be comparable to the relative importance of these considerations in other labor mobility decisions. The results of this survey information on the migration decision indicate a large fraction of all migration is based on an economic and job-related rationale. This "large fraction" compares favorably with that found for other forms of labor mobility traditionally analyzed with rather conventional economic models. Thus there appears to be great promise for economic models of the migration decision.

A number of migrants whose survey response on the decision to migrate indicated a non-economic rationale actually had economic considerations in mind when moving. However these economic considerations were generally not related to the terms or conditions of employment. But they do concern the real income available to migrants at different locations.

TABLE I:3:6

Detail Of Community Reasons For Migration By Whether The Move Was A Return Move Or Not

Reasons For Moving	Percent Of Heads Who Moved	
	Return Move	Not A Return Move
1. General Community Attractiveness	6	7
2. Personal Ties To Community	18	3
3. Repulsive Qualities Of Community Left	3	3
4. Other Community Reasons	3	3
5. Did Not Give Community Reasons (Gave Economic Reason)	70	84

From: Lansing, John, and Eva Mueller, op. cit., pg. 78

Table I:3:6 presents a detailed examination of the respondents to the Lansing and Mueller survey who reported that they moved for non-economic reasons. By far the most important non-economic category of reasons for migration concerned community reasons. "General community attractiveness" and "repulsive qualities of community left" account for about half of the community reasons for migration. This reflects the importance among primary responses of essentially consumption-related rationale for migration, based on: cost of living; climate; physical design; public goods availability; and related factors. Such a consumption-related rationale for migration is as much a part of real income considerations as unemployment or money wage levels at different locations. Indeed, it would be surprising if secondary responses of those who moved primarily for job-related reasons did not consider consumption characteristics of the destination in weighing different locations. Unfortunately tabulations of secondary reasons for migrating are not generally available.

Surveys of migrants are capable of providing even more detailed insight into the nature of the migrants' decision making process. Specifically characteristics of the extent and pattern of deliberation involved in the migration decision as well as the information used appears in the work of John Lansing and Eva Mueller.¹ Much of the remainder of this

¹ Lansing, John, and Eva Mueller, op. cit., Chapter IV.

relies on their work.

In general the length of time over which the migration decision is considered is short. Only 34% of the households that migrated in the Lansing and Mueller sample reported a period of serious deliberation in excess of six months. Indeed, 34% of the households considered the move seriously for one month or less. A follow-up survey one year later on those who reported that they might move in the next year confirmed the indications of short deliberation periods. Only 40% of those who said that they definitely planned to move had moved one year later and 3% of those who had no plans to move actually moved. Since the latter group who had no moving plans was far larger in absolute numbers than those who anticipated moving, the group of actual movers one year later contained a majority of individuals who had no plans to move in the first survey.¹ This indicates that the period of deliberation given to both the decision to migrate at all and to the exact destination of the move is short. Time constraints placed on job offers and transfers may account for some of this suddenness in the migration decision, but the haste with which families decide to move is still surprising.

Another important attribute of the migration decision is the sources of information which migrants use in deciding to

¹Lansing, John, and Eva Mueller, op. cit., pp. 209-210.

move and in locating employment in other areas. The classic source on such information is Clark Kerr's survey of migrants who came to Seattle in 1940-42 to work in the aircraft and shipbuilding industries. Kerr found that about 45% of those interviewed found their job through friends and relatives and another 35% responded to advertisements.¹ Most other studies of information sources have not separated migrants from other job changers. An exception is the information study made by

TABLE I:3:7

Use And Usefulness Of Sources Of Specific Information On
Jobs Reported By Migrants

Source Of Information	Percent Helpful	Finding Source: Not Helpful	N.A.	Did Not Use Source
1. Friends, Relatives	41	4	3	52
2. Special Trip	26	3	5	66
3. Employer's Rep.	12	1	1	86
4. Newspaper Ads.	8	4	1	87
5. State Employ. Agency	3	3	1	93
6. Private Employ. Agency	5	2	1	92
7. Unions	2	1	1	96

From: Lansing, John, and Eva Mueller, op. cit., pg. 228.

¹Kerr, Clark, "Migration to the Seattle Labor Market Area, 1940-42," reported in: Parnes, Herbert, Research On Labor Mobility And Labor Allocation, (N.Y.: Social Science Council) 1954, pg. 165. A significant fraction of migrants using other data sources found their jobs through government agencies, indeed some of the shipyards were government-owned.

Lansing and Mueller and reproduced in Table I:3:7. The importance of isolating information sources used by migrants can be seen from the Lansing and Mueller analysis. Because migrants are relatively heavily concentrated in white collar occupations and must secure information on jobs at a distance, they tend to rely on a different combination of information sources than job changers in general.¹ Friends and relatives are the most important sources of information and are most instrumental in finding jobs for all classes of migrants and job changers. But migrants tend to rely on special trips and employer's representatives to provide specific information on job opportunities. Newspaper advertisements, state employment agencies, private employment agencies, and unions are among the sources used infrequently or neglected completely.

The combination of short deliberation periods and limited and imprecise sources of information on job opportunities suggests that, for most workers, the migration decision is a creature of limited rationality at best. Certainly the results discussed thus far indicate that the search for employment is limited in extent. Most workers probably have close relatives and friends at few other locations while special trips and employer representatives are very specific and limited sources of information about economic conditions in other areas.

¹

The relationship between migration and skill is in Ch. IV.

Associated with the lack of extensive deliberation in the migration decision is a failure to consider many alternative locations. Indeed 64% of the Lansing and Mueller sample of approximately 5,000 interstate movers said that they considered no alternative locations before moving. Even among professional and technical workers, who participate in broad spatial labor markets, 56% considered only one destination. For other white collar and blue collar workers the results were 80% and 78% respectively.¹ There was neither a strong nor a uniform tendency for consideration of alternatives to increase with longer deliberation periods. This does not prove that individuals were unaware of employment opportunities at other locations. But it is apparent that workers seldom made an effort to investigate vacancies intensively in more than one area other than their home. This confirms the picture of a hasty migration decision painted earlier.

A final concept examined in the survey research literature on migration is the reservation wage. Surveys of workers, particularly the unemployed, indicate that many individuals attach a minimum wage to their labor services. This minimum expected or reservation wage varies directly with the skill level of the worker. Table I:3:8 illustrates this relationship.

¹Lansing, John, and Eva Mueller, op. cit., pg. 221.

TABLE I:3:8

Percentage Of Blue Collar Workers Having A Minimum Wage
In Mind When Looking For A New Job By Sex And Skill

Sex And Skill	Percentage With A Minimum Wage
All Skills And Both Sexes	69%
Males Only	72%
Skilled Males	79%
Semiskilled Males	71%
Unskilled Males	67%
Females Only	62%
Skilled & Semiskilled Females	71%
Unskilled Females	58%

Minimum Wage Expectations Of Blue Collar Workers When
Looking For A New Job

Wage Expectations	All Workers	Males	Females
\$30-50 Per Week	25%	14%	50%
\$51-60 Per Week	17%	11%	30%
\$61-80 Per Week	32%	39%	18%
\$81+ Per Week	26%	36%	2%
Average Wage Expected	\$65.02	\$71.23	\$50.89
Average Wage Accepted	\$86.55	\$95.16	\$63.16
Percentage Of Minimum Expected Wage Below Accepted Wage	24%	25%	19%

From: Sheppard, Harold L., and A. Harvey Belitsky, The Job Hunt, The Up-John Institute For Employment Research, (Baltimore, Maryland: Johns Hopkins University Press), 1966, pgs. 39 and 40.

It appears that about 70% of the workers in the sample on which Table I:3:8 is based had a form of reservation wage that increased roughly with the skill and earnings expected for the individual worker. Average wages in jobs actually accepted by the workers surveyed were 20 to 25 percent higher than the reservation or minimum expected wage. The study also determined that only 20 percent of the workers actually refused a job offer. The divergence between accepted and reservation wages and the small number of rejected job offers indicates that workers were willing to take a job and continue search in their spare time. It appears that average wages attached to job vacancies in the area surveyed, (Erie, Pennsylvania), were about 20 percent above the reservation wage. It would appear that individuals who might accept a wage offer as low as the reservation wage would plan on continueing their search effort while employed. Indeed this intention to continue searching after accepting a position may explain the relatively low level of reservation wages and the reluctance of workers to turn down a job offer.

Unfortunately there has been no extensive investigation of the importance of a reservation wage for samples consisting exclusively of intercounty migrants. Unlike workers considering jobs in their home labor market, those who must migrate

to accept a new position are unlikely to plan additional search in their local labor market. Thus for the migrant the decision to accept a position at a distance reflects a long-run commitment to employment in the destination labor market. Similarly any reservation wage associated with migration to a different area must be based on a long-run employment decision.

Results provided by the survey literature on migrants will be a powerful source of empirical evidence for the job-search model of migration developed here. The reservation wage will be among the most important of the concepts derived from the survey literature.

CHAPTER II

THEORETICAL RESEARCH ON MIGRATION

There have been few attempts to develop models of the determinants of migration processes that could be integrated into the body of economic theory. An exception is the attempt to analyze migration as an investment in human capital. Another approach has involved the analysis of migration as an equilibrating force in interregional growth models. Finally a number of aggregate models of migrant flows have been proposed based on "gravity" models and other functional forms of spatial interaction that have proved useful in geography and regional science.

II:1) Migration As An Investment In Human Capital

Most migration is undertaken not for the pleasure which moving might bring, or for the stimulation of new places, but rather in order to obtain more satisfactory employment.¹ This implies that the individual undertakes costs of moving in order to change the location of his labor services to an area in which the productivity of these services could be greater. Larry Sjaastad was the first author to propose that migration be considered an investment in human capital, in the same sense that changing the location of a piece of physical

¹The survey research literature reviewed in Chapter I indicates that as many as half of all moves are made primarily for employment-related reasons.

capital represents an investment.¹ When dealing with human beings, however, there is some difficulty in distinguishing consumption from investment. Nevertheless the human capital model has had some success in explaining characteristics of migration flows and patterns of differential migration.

Each individual at his initial location possesses a stock of human capital including: education; skills; health; job rights; location; etc. By selling the services of these aspects of their labor services in the local labor market workers can realize a stream of earnings over their working lives. Earning streams are available at other locations to individuals similarly endowed. The relative value of the streams at different locations may be compared by finding the appropriate discount rate, quantifying the costs involved in migration, and computing the present value of the earnings over time.² If the act of moving is an investment then equilibrium among local labor markets is achieved when the expected value of relative wages in different areas is such

¹Sjaastad, Larry A., "The Costs And Returns Of Migration," Journal Of Political Economy, Vol. LXX, (Oct. 1962), pp.80-93.

²This computation is actually quite complex, depending on proper determination of the discount rate; expected value and variance, or more generally the distribution of wages at all locations; and the degree of risk preference of migrants. If $f(y_{ij}, t)$ is the probability density function of the difference in wages between location i and j at time t , and r is the rate of discount, then the expected value of the present value of migration from i to j is:

$$E(V_{ij}) = \int_0^T \int_0^T e^{-rt} f(y_{ij}, t) dy dt$$

where; T is the number of years until retirement

that the present value of changing the location of any worker's human capital is not greater than moving costs.¹ This is essentially the same condition that characterizes an equilibrium for any durable good in a system of markets with positive transportation costs.

The descriptive statistics on migration in the United States presented in Chapter I indicate that population flows do not follow patterns characteristic of capital or durable goods subject to positive transportation costs. First, population movements follow particular paths connecting individual origins and destinations in a fashion that ignores relative transportation costs.² Secondly, even when the apparent incentive to migrate is great, as measured by relative wages or earnings, large reverse migration flows are found. These reverse flows do not reflect an aggregation problem, as has been suggested, with outmigrants having different skills than immigrants.³ Indeed return migrants are

¹This does not imply equality of wages or earnings for similar occupations even in a world of perfect competition. Scarce and immobile resources, such as favorable climate, are sufficient to insure wage differentials. However, the real income or attractiveness at all locations will be equalized.

²A number of authors have reported narrow migration paths that have dominated the relationship between particular origins and destinations. This special association has been called "chain" migration. See, for example; Lurie, Melvin, and Elton Rayack, "Racial Differences In Migration And Job Search," Southern Economic Journal, Vol. XXIII, No. 1, (July, 1966)

³This explanation of the high ratio of gross to net flows is often offered in the human capital literature. See, for example; Sjaastad, Larry A., op. cit., pg. 82.

relatively over-represented in the reverse migration flows. Thus we are left with the curious picture of the migration "investment" systematically reversing itself. It seems unlikely that flows of capital equipment follow such a pattern. Finally, differential migration rates for various age groups cannot be explained, as is often claimed, on the basis of differences in the present value of wage differentials due to the longer working life of the young. Differences in the present value of wage streams contributed by earnings differentials after the first 25 years are quite small in relation to the differential migration rates between the 25-29 and 30-35 year old age cohorts.¹

As a positive theory of migration processes the human capital approach leaves much to be desired. Data on actual migration flows indicate substantially different patterns of movement than those which would characterize movement of durable goods in or among spatially differentiated markets.

The normative implications of the human capital approach to migration have received most attention. Indeed the model achieves much of its significance because it is consistent with

¹The relative migration rate of individuals 25-29 years of age, adjusted for differences in education, is 40% higher than that for individuals 30-34 years old. It seems unlikely that much of this difference is due to the longer period of time which the younger group has until retirement. In Chapter IV:2 an alternate explanation for these migration differentials is discussed. The 30-34 year old cohort has 25 years until retirement and the present value of a \$1000 earnings differential in annual earnings 25 years hence discounted at 6% is only \$221.

normative economic theory. Rates of return accruing to investment in migration between particular points have been estimated by comparing earnings of migrants and non-migrants.¹ Observations of large positive annual earnings differentials are taken as evidence of potential gains from encouraging migration. The existence of negative earnings differentials accompanying sizable return population flows is largely ignored. Discouraging these return flows could achieve the same net population redistribution as encouraging additional migration with a saving in transportation costs.

The confusion over optimal levels of migration arises from attempts to associate earnings exclusively with migration. This is misleading for two reasons. First, there are gains from migration that are not reflected in earnings. The willingness of employers to incur recruiting costs, indicated by survey research results in Chapter I:3, reflects an anticipated gain to employers which will be analyzed in Chapter III. Secondly, part of the increase in earnings experienced by migrants reflects a return to activities other than migration itself. Typically a migrant is not a person who buys a bus ticket at random. A process of acquiring information about opportunities and even securing a job which

¹See, for example, Wertheimer, Richard, op. cit., pg. 40.

is more attractive than the migrant's present position usually preceeds the act of moving. This process involves explicit costs of acquiring information and implicit costs of time and wages forgone in searching job opportunities. In some cases the search process make take the form of a special trip or even temporary residence at a particular destination.¹

Individuals actually recorded as migrants represent the subgroup of all those who search for opportunities at a destination who actually find attractive employment positions at that location.² The increase in earnings which migrants experience overstates the rewards to all those who search for opportunities at a particular destination. The largest fraction of the observed increase in earnings of those observed as migrants may represent a return to search activity.

Failure of the human capital approach to migration to recognize the importance of search costs has led to questionable policy recommendations. Even in the case of non-white migration from south to north, the observation of large earnings increases accruing to individuals who came from

¹ Both of these search methods were mentioned in the survey research literature reviewed in Chapter I:3.

² Typical studies producing such results include: Bowman, Mary, and Robert Myers, "Schooling Experience and Gains and Losses in Human Capital Through Migration," Journal of the American Statistical Association, Vol. LXII, (September, 1967) and Bowles, Samuel, "Empirical Tests of the Human Investment Approach to Geographic Mobility," Discussion Paper #51, Program On Regional and Urban Economics, Harvard University, (July, 1969)

the southern states took place only after five years of residence in the North.¹ The group that is not considered consists of non-white southerners who search for opportunities in the North, in many cases migrating temporarily, and then return to the South. Both the relatively low earnings of recent non-white arrivals in the North and additional research which shows that the relative non-white to white unemployment rate is higher in the North than in the South, indicate the extreme difficulties experienced by non-whites attempting to secure employment in the North.² Failure to consider such costs of search has been a serious impediment to attempts to draw normative implications from the human capital approach to migration.

II:2) Migration In Aggregate Regional Growth Models

In a system of regions where migration is unobstructed, capital markets well organized and integrated, possibilities for substitution of capital and labor in production extensive, and free trade of goods hindered only by modest transportation costs, there is a strong presumption that factor prices in

¹The basic result that there was no significant difference in the earnings, adjusted for age and skill, of non-whites who had migrated to the North versus those remaining in the South for the first five years was reported in: Wertheimer, Richard, The Monetary Rewards Of Migration In The U.S., (Washington, D.C.:The Urban Institute), March, 1970, pg. 38.

²Rapping, Leonard, "Unionism, Migration, and the Male Non-White -White Unemployment Differential," Southern Economic Journal, Vol. 32, No. 3, (July, 1966), pp. 317-329.

in various regions will be equalized over time.¹ However, some differences in factor prices would be expected in equilibrium situations, particularly differences in wages of labor, due to differences in natural resource endowments among regions. Thus areas with more benign climate and greater scenic attraction would, *ceteris paribus*, have lower wage rates. The return from such elements of attractiveness would appear as rent to the land areas endowed with such favorable attributes.

Equilibrium in a system of regions, while characterized by factor price equalization with the exceptions noted above, does not imply an absence of net flows of factors between regions. Indeed in a condition of steady state growth one would expect areas with relatively high birth rates and low saving rates to be net exporters of population and/or importers of capital. Thus migration models remain as a topic of some interest even for a system of regions near an equilibrium.

Factor price equalization can theoretically be accomplished through: shifts in output mix of regions; extensive substitutability of factors of production; migration of mobile factors of production. A major problem confronting models of economic growth among regions has been to account for the

¹ Far more restrictive conditions will still produce factor price equalization. See, for example, the seminal article on this topic: Samuelson, Paul A., and Wolfgang Stolper, "Protection and Real Wages," Review Of Economic Studies, Vol. IX, (1941), pp. 58-73.

relative importance of these various mechanisms for adjusting to disequilibria in factor prices and production patterns among regions. Sometimes the mechanisms of factor price adjustment are readily observable. For example, relocation by firms in the textile industry of production facilities, formerly in the North, to the South, represents both a capital migration and a shift in output mix between the two regions.

Interstate wage differentials in the United States have narrowed during the twentieth century. The relative wage differential for manufacturing workers in southern vs northern states narrowed from about 100% in 1907 to about 20% by 1947.¹ Subsequent studies have found that the money wage differential between these areas has remained stable at 20% through the 1960's.² Some of this continuing differential undoubtedly reflects errors inherent in treating labor as a homogeneous factor. Even within specific industry categories there are differences in average skill-education levels of workers in the South and North. Adjustment for these skill differences has been shown to account for about half of the 20% wage differential. Finally it appears that prices of goods and services are higher in the North and that the

¹ Fuchs, Victor, and Richard Perlman, "Recent Trends In Southern Wage Differentials," Review of Economics and Statistics, XLII, (1960), pp. 292-300.

² Scully, Gerald, "Interstate Wage Differentials," American Economic Review, (December, 1969), pp. 757-773.

natural resource endowment of the South is more attractive to workers. The movement of retired persons, who are largely independent of the labor market, indicates a preference for milder climates that is probably shared by the general population.¹ Unfortunately it is not clear that effects of climate have been separated from cost of living factors in assessing relative attractiveness of various regions. To the extent that the natural endowment of the South is more attractive than that of the North, analysis of factor price equalization implies an equilibrium in which real wages in the North would be higher.

The empirical evidence reviewed above suggests that the first half of the twentieth century represents the most fruitful period in which to observe the processes of relative wages among regions moving toward an equilibrium. The major sources of the large disequilibrium at the beginning of the century were residual effects of the War Between the States, which had devastated the economy of the South, and improvements in transportation which opened vast areas of the United States to settlement.² A number of studies have attempted to isolate sources of regional growth during this period and to

¹For a study showing an empirical association between climate and migratory preferences, see: Greenwood, Michael J., "Lagged Response In The Decision To Migrate," Journal Of Regional Science, Vol. 10, No. 3, (December, 1970), pp. 375-384.

²Miller, Ann Rather, "Labor Force Trends And Differentials," in Simon Kuznets, et. al., op. cit., pp. 20-70.

judge the relative importance of movements of capital, migration of labor, and changes in output mix in accounting for movements in relative factor prices. On balance this literature serves better as a catalogue of the changes in employment, capital stock, and output among regions.

Perloff, et al found that for regions in the United States differential shift and proportional shift of economic activity were equally important in accounting for patterns of development.¹ Differential shift, the relative rate of growth of a given industry in various regions, appeared to be driven by what Perloff, et al regarded as "exogeneous" forces of population growth and migration creating new market areas. The difficulty here is that shifts in the factor market are also related to population growth and migration and these might induce employment growth.²

In his study of changes in location of employment in manufacturing within the United States, Victor Fuchs found that the existence of unions, dense population, and cool climates all appeared to inhibit growth of manufacturing employment.³ However money wages and the fraction of

¹ Perloff, Harvey, Edgar Dunn, Eric Lampard, and Richard Muth, Regions, Resources, and Economic Growth, (Baltimore, Md.: Johns Hopkins University Press), 1960.

² Such simultaneous equation effects are discussed in Chapter IV:3 and IV:4.

³ Fuchs, Victor, "Statistical Explanations for the Relative Shift of Manufacturing Among Regions of the U.S.," Papers and Proceedings of the Regional Science Assn., (1962) pp.105-26.

employment already in manufacturing had no significant relationship to changes in manufacturing employment. Fuchs and others have explained these results by noting that high wages can spur immigrant flows to an area but that they could also deflect investment.¹ Borts and Stein reached a similar conclusion after noting that capital-labor ratios and wages often increased fastest in high wage areas.² They also had little success in relating growth rates to industrial composition, concluding finally that a better understanding of the elasticity of supply of labor to a region was necessary to sorting out growth processes.

The absence of a consistent relationship between relative wages and subsequent wage and employment changes among regions is explained in Chapter IV both in terms of a job-search model of migration and empirical problems associated with the use of aggregate wage data.

II:3) Models Based On Rules For Spatial Interaction

The inspiration for most empirical work on migration has been the "gravity" model of spatial interaction. The development of these models will be examined in some detail because,

¹This is the essence of the simultaneous equation problem arising because wages and migration flows are endogeneous.

²Borts, George, and Jerome Stein, Economic Growth In A Free Market, (New York: Columbia University Press), 1964, pp. 61-69.

by some coincidence, the "gravity" models bear some resemblance to the functional forms of the job-search models of migration which will be developed in Chapter III.

The "gravity" model of spatial interaction, as first formulated by Zipf, based gross migration flows between two places directly on the product of their respective populations and inversely on the distance between the areas.¹

$$\text{II:3:1)} \quad M_{ij} + M_{ji} = k P_i P_j / D_{ij}$$

where: M_{ij} = the number of migrants from i to j

P_i & P_j = populations of i and j respectively

D_{ij} = is the distance between i and j .

The analogy with Newton's law of gravitational attraction is obvious. Although there have been periodic attempts to find an economic rationale for the Zipf formulation, and its many modifications, the basic a priori appeal of the relationship rests on a simple statistical regularity.² Consider a population in which the probability of interaction between any two individuals is equal for all individuals. If the population is partitioned into n groups, P_1, P_2, \dots, P_n , the expected value of the amount of interaction between the individuals in any two groups, i and j , will be proportional to $2P_i P_j$ or

¹Zipf, George K., "The $P_1 P_2 / D$ Hypothesis on the Intercity Movement of Persons," American Sociological Review, Vol. XI, (1946), pp. 677-686

²For a recent attempt at an economic derivation of the "gravity" model see: Neidercorn, John H., and B.V. Bechdolf Jr., "An Economic Derivation of the Gravity Law of Spatial Interaction," Journal of Regional Science, (Dec., 1969), pp. 273-281.

to a constant multiple of $P_i P_j$. Of course if the partition into groups is made on the basis of some factor that effects the likelihood of interaction, such as distance between individuals in the case of different city populations, that factor would alter the expression for the expected value of the level of interaction.

A seemingly logical next step for "gravity" models was to break down gross flows into their respective net flows between areas. The basic technique, first developed by Somermeijer, involved the assumption that the fraction of gross flows to be allocated to each direction depended on the relative attractiveness of the two areas.¹

$$\text{II:3:2)} \quad M_{ij} = (\frac{1}{2}k + K A_j/A_i) P_i P_j / D_{ij}$$

$$\text{II:3:3)} \quad M_{ji} = (\frac{1}{2}k - K A_j/A_i) P_i P_j / D_{ij}$$

where: A_j and A_i = indexes of attractiveness

K and k = constants

Note that adding II:3:2 and II:3:3 gives the gross flows equation between the areas which is identical with II:3:1. Thus the basic assumption of a true "gravity" model is that gross migration flows are independent of the difference in the relative attractiveness of the two areas.

More recent "gravity" models of net migration flows have followed a functional form similar to that adopted for use with

¹Somermeijer, W.H., "Een Analyse Van De Binnenlandse Migratie In Nederland Tot 1947 En Van 1948-1957," Statistische en Econometrische Onderzoekingen, (1961), pp. 115-174.

linear econometric estimators by Lowry.¹

$$\text{II:3:4)} \quad M_{ij} = k (U_i^{a1}/U_j^{a2}) (W_j^{b1}/W_i^{b2}) (L_i^{c1}) (L_j^{c2}) (D_{ij}^{c3})$$

where: U_i and U_j = unemployment rates in the non-agricultural labor force at i and j respectively

W_i and W_j = average hourly earnings in manufacturing at i and j respectively

L_i and L_j = non-agricultural labor force at i and j respectively

D_{ij} = airline distance from i to j .

The variables corresponding to the Somermeijer attractiveness function are unemployment and wage rates at i and j . The separation of relative unemployment rates from relative wage rates is designed to reflect Lowry's hypothesis that job availability, as determined by unemployment rates, and wage rates are separable aspects of attractiveness.² One might equally contend that expected earnings at each location, equal to the product of wages and the employment rate, determined attractiveness and still estimate the same functional form as Lowry. While a number of specific behavioral hypotheses might be compatible with the Lowry model, no particular microeconomic justification was pursued very far by the author. Indeed there has been little attention given to the

¹Lowry, Ira S., Migration and Metropolitan Growth: Two Analytical Models, (Chandler Publishing Co.: San Francisco, California), 1966, pg. 12.

²Lowry, Ira S., ibid., pg. 13.

incompatibility of the Lowry formulation with the fundamental theorem of "gravity" models, that gross flows are independent of relative attractiveness of the areas. In II:3:4, gross migration is made an increasing function of differences in attractiveness between the areas. The net migration models based on the Lowry formulation should be regarded as a departure from true "gravity" models, with the $L_i^{C1} L_j^{C2} / D_{ij}^{C3}$ term now serving as a scaling factor. In view of the limited justification for the initial gravity formulation, Lowry's arbitrary reformulation is understandable.¹

Migration equations similar to II:3:4 have been tested against a wide range of data sources.² The most dramatic result of these empirical tests has been the persistent failure of economic conditions at the origin, particularly wages and unemployment rates, to be significantly related to migration.³ Coefficients of destination wages and particularly unemployment have usually been statistically significant.

This assymetry in the significance of attractiveness

¹The arbitrary nature of the reformulation is indicated in Lowry's own footnote: Lowry, Ira S., Ibid., pg. 12.

²See, for example: Rodgers, Andrei, "A Regression Analysis Of Interregional Migration In California," Review of Economics And Statistics, Vol. 29, (1967), pp. 262-276.

³An important exception to this result is found in: Masser, I., "A Test Of Some Models For Predicting Movement Of Population In England And Wales," Working Paper #9, Center For Environmental Studies, London, England, (March, 1970), pg. 19.

indexes at the origin and destination arises out of a departure from the spirit of the "gravity" model relationship. Equations II:3:2 and II:3:3 suggest that population flows in each direction depend on the relative attractiveness of the two areas, and not on the absolute levels of attractiveness. This suggests that the coefficients of wages and unemployment be constrained to be equal, $b_1 = b_2$ and $a_1 = a_2$. Indeed unless such a relationship is adopted the implied formulation suggests that migration increases with a rise in wages or fall in unemployment rates. Lowry does report, in a footnote, that he tested a relative attractiveness formulation and found it insignificant before moving on to his final equation.¹ Such trial-and-error approaches are not likely to yield meaningful results.

In view of this wholesale rejection of the a priori information in equations II:3:1 and II:3:2, one might say that the Lowry model, and its many derivatives, are more noted for their departures from than their application of the implications of the "gravity" model. The essentially arbitrary or accidental nature of these quasi-gravity models should be recognized when drawing inferences from estimated values of their parameters.

A second problem that has been most troublesome to users

¹Lowry, Ira, ibid., pg. 13

of the Lowry formulation has been the possibility of simultaneous equation bias. This is particularly important in the case of unemployment rates where migration directly affects the size of the labor force, one of the arguments of the function determining unemployment rates. It is most difficult to accept unemployment as an exogeneous variable. This suspicion is reinforced by empirical studies based on data from California and the United Kingdom which showed that the coefficient of destination unemployment, while statistically significant, had the wrong sign, b_1 was positive.¹

There is some precedent for assuming wages to be exogeneous in a migration equation. The argument is based on a job-rationing model of the labor force. Money wages are assumed to be inflexible in the short run. Any excess supply of labor in each location must then adjust to preserve unemployment rate differentials among labor market areas. Employment changes at various locations are exogeneous responses to changes in demand or investment or technology or prices of non-labor inputs. The extreme statement of the job-rationing model, developed by Cicely Blanco, relates migration during a time period to the unemployment rate implied by the difference between unemployment at the conclusion of the time period and the projected size of the work force due to natural increase

¹See, for results from California, Rogers, Andrei, op. cit., pg. 265, and for results from the United Kingdom, Masser, I., op. cit., pg. 19.

at the end of the time period.¹

$$\text{II:3:5) } NM_t = a + b_1 (E_t - L_t) + b_2 (E_{t-1} - L_{t-1})$$

where: NM = net migration during the time period

E_t = employment at the end of the time period

L_t = labor force at the end of the time period based on natural increase with no migration

E_{t-1} = initial employment level

L_{t-1} = initial labor force.

A number of variations of this model have been developed.²

The basic functional form suffers from additional problems that are discussed in appendix II-A at the end of this chapter. The assumption of wage rigidities and job-rationing may be reasonable for one or perhaps even the five year period required for the Lowry model. But this is an empirical question and must be regarded as extremely suspect when applied to models of migration flows over a decade as in much of this literature.

Actually an elaborate rationalization for the absence of a relationship between wage changes and employment, and hence for the job-rationing model, was developed for long-run models. Most interesting is the hypothesis of Borts and Stein that

¹Blanco, Cicely, "Prospective Unemployment and Interstate Population Movements," Review of Economics and Statistics (May, 1964), pp. 221 and 222.

²For example, see: Mazek, Warren, "Unemployment and the Efficacy of Migration," Journal of Regional Science, Vol. 9, No. 1, (April, 1969), pp. 101-107.

the demand for labor in particular labor markets is perfectly elastic.¹ The basic driving force of economic growth in a local area is assumed to be provided by industries selling in a national market. The demand curve facing these export base industries is assumed to be perfectly elastic at prevailing national price levels since any one city supplies only a small fraction of national output. Then, assuming elastic supplies of capital and other non-labor inputs, and constant returns to scale, the demand for labor will be highly elastic. In such a world, net migration or any other force shifting the supply of labor schedule affects employment and output of the area but not wages. This is a long-run argument for job-rationing models, with a reversed causality in which migration determines employment and output.

One flaw in the Borts and Stein hypothesis lies in the assumption of highly elastic demand for exports. For many cities, export industries do provide a large fraction of national demand.² Also in a world of positive transportation costs every plant and every city will face a downward sloping demand curve reflecting the horizontal summation of demand curves at increasingly distant points. This is a fundamental result of spatial pricing models.

¹Borts, George, and Jerome Stein, op. cit., pp. 210-220.

²The classic demonstration of this point is found in; Lightenberg, Robert M., One-Tenth of a Nation, (Cambridge, Massachusetts: Harvard University Press), 1960, pp. 265-268.

The Borts and Stein hypothesis along with recent attempts to test it in simultaneous equation models is the subject of detailed analysis in Chapter IV:4. There it is shown that the interaction between aggregation and simultaneous equation problems virtually precludes estimation and identification of the demand for labor curve given present data sources.

The literature on migration reviewed thus far suggests two conclusions for further research. First additional generalizations drawn from empirical regularities are not needed. Too many results of this sort already exist and they tend to be contradictory. The extreme statement of this contradiction is seen in the assumption of perfectly elastic labor supply made in the job-rationing literature and the assumption of perfectly elastic demand for labor in the Borts and Stein models. Our understanding of migration has advanced little since Ravenstein's work. Secondly any attempt to build a microeconomics of migration must reconcile contradictions in the literature and account for empirical results from both the survey research and econometric model literature. The next chapters attempt such a formulation.

APPENDIX TO CHAPTER II

Most models of migration have related numbers of migrants to the relative attractiveness of origin and destination areas as indicated by wages, climate, unemployment, etc. Not only have most of these formulations had little analytical content, but the majority have even ignored basic desirable properties which any migration function should have. One such property is that when two areas are equally attractive there should be no net flow of migrants between them. Any careful formulation should take into account this piece of a priori information, yet most migration functions in the literature do not.

The most common functional form for migration equations has related the fraction of the population at a particular origin that migrated in a given time period to the attractiveness or relative attractiveness of that area and a given destination. But this formulation, however desirable on other criteria, is inconsistent with the desirable property that equal attractiveness in both areas produce zero net migration.

Consider a world in which all areas are equally attractive. Interpreting this to mean that the fraction of total population in any area migrating in a given time period is equal for all areas, gives:

$$\text{II:A:1)} \quad M_{ij}/N_i = z_{ij} / z_i$$

where: M_{ij} = migrants from i to destination j

N_i = population of area i

z_{ij} = fraction of population at i that migrates to j

z_i = fraction of population at i that migrates to any of the equally attractive destinations.

Similarly, using analogous notation to that in II:A:1, the number of migrants from j to i is:

$$\text{II:A:2)} \quad M_{ji}/N_j = x_{ji} \neq x_j$$

Now it has been agreed that if both areas are equally attractive net migration should be zero. This does not, however, imply that $z_{ij} = z_i$ or that $x_{ij} = x_i$ or that $z_{ij} = x_{ij}$, as is implied by most migration equations. Indeed zero net migration requires that the fraction of migrants from different areas be unequal. Consider the situation in which i and j have equal migration flows in each direction.

$$\text{II:A:3)} \quad M_{ij} - M_{ji} = 0 = z_{ij} N_i - x_{ji} N_j$$

Clearly in this instance of zero net migration the fraction of out-migration from each area depends on the population ratios of the two areas.

$$\text{II:A:4)} \quad z_{ij}/x_{ji} = N_j/N_i$$

Only if both areas have identical population does zero net migration imply equal probability of out-migration from both areas.

Thus if all areas are equally attractive and there is no net migration the fraction of out-migration from areas with relatively large population will be small than that for

areas with small population.

CHAPTER III

A JOB-SEARCH MODEL OF MIGRATION

This chapter develops a job-search model of migration among metropolitan areas. The model is based on concepts first described in the literature on the economics of information. This literature is surveyed first and the special applicability of the economics of information to migration, as opposed to other labor market applications commonly referred to as the job-search models. Subsequent sections will build a microeconomics of migration, both in terms of decisions by workers and behavior of employers.

III:1) The Economics Of Information And Job Search

The first attempts to formulate an economics of information as a formal part of microeconomic theory are generally credited to George Stigler.¹ In formulating an economics of information, Stigler's first step was to note that positive costs of search to both buyers and sellers implied that a traditional pareto optimal market-clearing solution was the exception rather than the rule in real-world markets. Economic actors engage in recontracting and search only to the extent that the marginal return to such activities exceeds the marginal cost. This accounts for the distribution of

¹Stigler, George, "The Economics of Information," Journal of Political Economy, (June, 1961), pp. 211-225.

of prices that are commonly observed for identical goods and services. Thus buyers cannot be expected to search out the lowest price offered by any seller.

Given that they face distributions of bid (asked) prices, sellers (buyers) can expect that, for most distributions, there will be diminishing returns to search. The expected value of maximum (minimum) price found by sellers (buyers) increases (decreases) at a diminishing rate with additional search efforts. Much emphasis has been placed on this marginal benefit from search function while the marginal search cost function has been neglected. In general investigators have had models of a single buyer or seller engaged in personal examination of successive possible transactions. The average cost per opportunity searched is usually assumed constant or slightly increasing if the most convenient opportunities are searched first. However, it is possible that due to learning effects involved in the search process the average cost per search may decrease over a wide range. Several recent articles have explored the extent of search expected of workers by simulating markets subject to given price distributions and search cost functions.¹ The major result of these efforts has been to show that only a very limited

¹See, for example: Gastwirth, Joseph L., "On Probabilistic Models Of Consumer Search For Information," Working Paper, Harvard University, (June, 1971)

amount of search can be expected in most cases, and for most goods.

Presently there has been no development of general equilibrium analysis of an economy with positive search costs. Indeed there has been little work on a theory of consumer's demand in which prices of all goods are stochastic, and information is costly. Unfortunately migration does involve such a choice among many goods since the decision to locate in a particular area is analogous to the choice among commodities. Similarly information on wages is analogous to information on prices, both being stochastic variables.

Clearly the way to preserve the notion of pareto optimality and its welfare implications in a market with positive search costs and uncertain prices is to consider search as an economic activity. This means that there will no longer be a single price for homogeneous goods that clears the market but a distribution of prices. Presumably the variance of the distribution of prices for a particular good varies directly with the cost of search. In the extreme cases of zero and infinite search costs, prices become perfectly deterministic and undetermined respectively. Unfortunately relatively few other results on search costs and price distributions have

been developed. If the only result of the economics of information were to account for the observation that the market price of homogeneous goods is not uniform, it would amount to little more than a footnote to deterministic microeconomic models.

The most interesting applications of the economics of information have been in the form of job-search models of labor market behavior. Job-search is the activity of gaining information about employment activities. Optimal search calls for workers to examine successive job opportunities with an wage criterion in mind. The first analysis of information in the labor market was made by George Stigler.¹ Most of his results were analogous to those mentioned above for the general economics of information. The dispersion of wage offers was related directly to search costs both in theory and in limited empirical tests.² Also concrete expressions for the marginal benefit from additional search were developed for given wage distributions. The marginal benefit from additional search is equal to the expected value of the increase in the maximum wage found when total searches are increased. One optimal decision rule for workers in such a labor market involves formulation of an acceptance wage by each worker

¹Stigler, George, "Information in the Labor Market," Journal of Political Economy, (October, 1962), pp. 94-105.

²Stigler, George, ibid., pg. 97.

which represents the wage at which he will take a job and cease search. Generally speaking the acceptance wage is determined by finding the wage level at which the expected value of additional wage increases is less than the costs associated with additional search.

At least three features of the search process are vital to the formulation of an acceptance wage, and to the nature of the resulting job-search model. First is the question of offer stockpiling. Can the worker retain an offer while he searches further, or must an immediate decision be made? Secondly the worker's knowledge of the actual distribution of wages is important. The search process yields information on the distribution being sampled. If knowledge of the actual distribution is meagre, search activity may also cause the estimate of this distribution to change. Under such circumstances, the properties of the acceptance wage become most complex, as is so often the case when learning processes are modeled.¹ Third is the possibility of workers resampling firms. Even if no openings were available at a particular firm, the applicant should become aware of the prevailing wages and working conditions. If the search period were rather long, workers might resample firms whose wages were relatively high but which, temporarily, had no vacancies.

¹Some attempts to deal with this problem are found in: Salop, S.C., "Systematic Job Search And Unemployment," Working Paper, Yale University Theory Workshop, undated.

Any job-search model must make some strong assumptions about the characteristics of job offers reviewed above.

One additional modification of the job-search model has caused it to assume its present prominence in the recent literature. The cost of search is assumed to be higher for employed than for unemployed individuals. Thus unemployed workers will decline job offers that are above the level of unemployment compensation that they could receive while out of work because accepting such employment, even on a temporary basis, could interfere with further search. Such behavior places the unemployed in a different light. The Bureau of Labor Statistics has long defined unemployed workers as those who indicate that they attempted to find work without success during the past week. The job-search formulation implies that these workers are engaged in useful economic activity, trying to place their human capital in its highest use. Their present status reflects a desire to continue high levels of search activity rather than be constrained by a job. Workers who perceive the distribution of wages to be higher than its actual level will tend to be recorded as unemployed for long periods. To a certain extent, the observation of high levels of job vacancies accompanying sizable unemployment may reflect the divergence of expectations and actual wages prevailing.

Unfortunately there is relatively little empirical evidence on the relative costs of job search for those employed and unemployed. Survey research results reviewed in Chapter I:3 suggest that few unemployed workers actually refuse a concrete job offer and that their reservation wage is about 25% below the average wage actually accepted. If relative search costs for the employed really interfered with job-search, more unemployed workers would turn down jobs and wages actually accepted would approximate reservation wages.¹ What is even more disturbing in most job-search models of unemployment and wage changes is the implicit assumption in many models that continued search while employed is virtually precluded by costs or other aspects of the search decision. This assumption often creeps into job-search models indirectly. The acceptance wage is found by solving for the offer which equates marginal costs of immediate search efforts with the present value of marginal expected gains from search. Present values of benefits are computed by discounting over the number of years until retirement. At a time in which one in three marriages ends in divorce and the sum of accessions and separations per year equals half the size of the labor force, it seems rather naïve for workers to discount values over long periods of time. Surely in many cases workers take jobs with the prospect of further search. In many cases, the accession

¹Chapter I:3 reviewed survey results showing accepted wages 25% above reservation wages.

is viewed as temporary by both the employer and employee.

In addition to the information presented above, survey research results are available on characteristics of local labor market search on the part of unemployed workers. Recently unemployed workers apparently concentrate their search effort shortly after job separation. After the first week of unemployment, the rate of search falls to one or two opportunities per week for the average worker.¹ It is difficult to believe that employment for forty hours per week could preclude such levels of activity, let alone part time employment.

Thus it is not obvious that the economics of information can be applied meaningfully to labor market activity. Past job-search models of local labor market activity have made strong assumptions concerning relative search costs when employed and unemployed and expected duration of employment. Both these assumptions appear to be in conflict with the limited empirical evidence available. The vast majority of job-search models appear to ignore these conflicts.² This will not be the case with the job-search model of migration developed here. Indeed the migration decision will be shown to be particularly well suited to a modified model based on the economics of information.

¹Sheppard, Harold, and Harvey Belitsky, The Job Hunt, (Baltimore, Maryland: Johns Hopkins Press), 1966, pg. 55.

²See, for example: Mortensen, Dale, "Job Search And Unemployment," American Economic Review, (July, 1970), pp. 847-861.

III:2) Migration And The Economics Of Information

The previous section catalogued a number of areas in which assumptions about the relationship between workers and job opportunities must be made in order to apply job-search models to particular labor market situations. Most important is the duration and durability of job acceptances. This issue will be considered first in relation to the migration decision to be modeled here.

Migration differs from the ordinary local labor market job acceptance decision. Previously the assumption that job-search activity was significantly constrained by employment was questioned. The decision to accept a job is not equivalent to nor does it imply a decision to cease search. However migration is costly. Both out-of-pocket moving costs and implicit social and psychological costs of changing location are involved in the migration decision. Although return flows of migrants are large, it would appear that migrants do regard the decision to accept a job at a distant location as a relatively long-run decision. In addition, job-search at a distance is costly, often involving special trips. Moving to a different labor market area means trading one set of local job opportunities for a new set. Obviously this does not guarantee that all future search will be concentrated at the destination. But, since the relative costs of search have been altered, certainly

the relative importance of the origin as a locus of search will be diminished.

Both the large transactions costs involved in moving and the change in relative search costs at the new location, indicate that the migration decision implies a long-run commitment to participate in the destination labor market. This result holds even if the worker exchanges unemployment at the origin for similar labor force status at the destination. Such moves are based on individual perceptions of the long-run return to search at different locations. This is consistent with the implicit assumption in job-search models that the job acceptance decision involves long-term comparisons and termination of search.

A number of other aspects of the employment decision were presented in the previous section as being critical to the application of the economics of information to labor market decisions. First was the question of offer stockpiling. It would seem that in the case of job offers at a distance some degree of negotiation and/or opportunity for consideration over time would be allowed by employers. Under these circumstances some offer stockpiling is possible.

Secondly there is a question of the degree of learning on the part of job searchers. Specifically learning involves

changes in a worker's perception of the actual distribution of wages as a result of search. Surveys of workers indicate that perceptions of wage levels and reservation wages are rather insensitive to the degree of search.¹ There is a fundamental difficulty involved in analyzing learning phenomena in a static equilibrium model. Presumably search causes the perceived wage distribution to approach the actual distribution. In dynamic models with changing wage rates it is possible to model this process. But in static models or equilibrium models, it is difficult to account for or describe the nature of any divergence of actual and perceived wages. Thus for static or equilibrium models of the sort that will be developed here the actual wage distribution will be assumed to be identical to the expected distribution.² No learning occurs during the search process. It may be that static models are less appropriate than dynamic models. Thus if origin wages are changing quickly there may be a significant difference in current and expected wages. Such expectations phenomena would be greatest at the origin because workers there have presumably experienced wage changes over time.³

¹ Kasper, H., "The Asking Price Of Labor And The Duration Of Unemployment," Review of Economics And Statistics, (May, 1967), pg. 145

² If there were any difference between actual and expected wages, search processes would logically modify worker expectations.

³ Dynamic models might show why origin wages have often proved insignificant in empirical studies. But the simultaneity between wage changes and migration would cloud the results obtained from any crossection data.

A third consideration is the possibility of resampling firms which had no appropriate vacancies when initially searched. This would appear to be an important phenomenon in local labor markets where many workers find employment through recalls or returning to places of previous employment. Recall or resampling on the basis of position on a waiting list would appear to be less likely when worker residence is distant from the firm. Unless a firm, which presently has no vacancies, anticipates an immanent change in workforce requirements, it will tend to confine its recall and job application files to local residents. Thus all search efforts at a distance will be regarded as new sampling or job-search efforts.

There are a number of questions that have particular relevance to the attempt to apply the economics of information to migration that do not arise in ordinary job-search models. Perhaps the most important difference in the migration decision is that workers are sampling from many wage distributions, each at a different location with its own search costs. If the migration decision is based only on wages, workers who were fully aware of the distribution of wages everywhere would only search for opportunities at one location. This does not imply that all search will be at a single destination because search costs will vary among individuals, even at a given location, and of course moving costs will also vary with distance from a

given origin. The tendency to concentrate search in one area when all wage distributions are known completely will be increased if the average cost of search decreases. The failure to consider alternative destinations agrees well with survey research accounts of the migration decision.¹ Unfortunately such assumptions of complete knowledge of wages are difficult to model analytically. The greatest difficulty can be seen by noting that the reservation wage of workers at one location bears no necessary relationship to the actual wages observed there. Reservation wages at any origin would be a weighted average of reservation wages based on wage distributions and search at a variety of alternative locations.

There are two obvious drawbacks or contradictions in assumptions of knowledge of wages elsewhere. First survey research suggests that most workers are only dimly acquainted with wages in the local labor market.² Job opportunities at more distant locations should prove even more obscure. Secondly search patterns of local workers, primarily the unemployed, indicate that the vast majority of search effort is concentrated within a metropolitan area. Few, if any, workers search more intensively at a distance than they do in the local labor market.

¹This result was presented in Chapter I:3. A majority of workers report considering no alternative destinations.

²For example, see: Parnes, Herbert, Research On Labor Mobility, op. cit., pg. 78.

A more realistic assumption concerning the degree of knowledge about wage distributions is that workers only have accurate information on prevailing wages in their local labor market. Indeed survey research evidence indicates that worker knowledge of local labor market conditions is often poor, lacking both precision and accuracy.¹ Under these circumstances the reservation wage for all workers within a labor market will be based on the distribution of wages and search costs in the metropolitan area. There will be a range or distribution of reservation wages even if all workers at a location know wages precisely, due to differences in worker attributes, and variations in search costs and present wages of employed workers.²

The mechanism of the migration decision operates to keep workers ignorant of opportunities elsewhere. If the reservation wage is based on local labor market conditions, then the individual who examines opportunities elsewhere will quickly reach one of two conclusions. Either he will find wages lower than those at the origin and terminate search or he will accept the first offer above his reservation wage. In this second case migration follows and search efforts are concentrated in

¹For an example showing that workers in lowest wage firms saw their wages near the median for the metropolitan area see: Parnes, Herbert, ibid., pg. 78.

²Thus even abstracting from differences in worker attributes, age, sex, skill, etc., reservation wages will differ.

the destination. Workers, having found an attractive offer elsewhere, cannot be expected to remain long in their initial location.

A second complication in applying the economics of information to the migration decision arises because choice of job and residential location is compounded. For most workers consumption is necessarily tied to the area in which they are employed. Migration involves a comparison of real wages defined in their most comprehensive sense. For this reason equilibrium in a system of labor markets does not even imply equality of wages adjusted for differences in cost of living. Differences in general amenity among areas, such as aspects of scenery, or climate, will cause equilibrium wages adjusted for the cost of living to diverge. Henceforth the term attractiveness will be used to refer to the composite of wages, cost of living, and amenity that characterizes an area.

A final peculiarity of the migration decision that affects direct application of the economics of information is the tendency of firms to bear a portion of search costs. Almost 40% of migrants who reported that they moved for economic reasons found their position through an employer's representative.¹ Of course, employers often assume a portion of search

¹Lansing, John and Eva Mueller, The Geographic Mobility Of Labor (Ann Arbor, Michigan: University of Michigan Press), 1967, pg. 231.

costs within local labor markets, but this labor market phenomenon has not been included in job-search models thus far.

It might seem that employer-financed search would be concentrated in local labor markets. Firms can be expected to search most intensively in areas where the return to search is high. There are regional disparities in wages paid for similar work.¹ There is some doubt of the ability of employers to capitalize on these wage differentials by paying migrants lower wages. Unions enforce uniform wage scales.² Even if these schedules can be avoided by changing job qualifications, firms paying low wages will experience high turnover rates. Once a worker has moved to a new job market he should quickly adjust to new wage rates. Unless there are barriers to labor mobility in the local labor market, newly arrived workers should soon demand the same level of compensation as others similarly situated in the local market. Cases in which massive labor importation has occurred usually accompany barriers of race, ethnicity, language, etc. that keep new arrivals out of the local labor market.³ Recent evidence of bounty payments for

¹See the discussion in Chapter I:2.

²See, for example: Rees, Albert, and Schultze, George, Workers And Wages In An Urban Labor Market, (Chicago, Ill.: University of Chicago Press), 1970, Chapter 4.

³Involuntary servitude was an extreme case of the attempt to insure that employers could capitalize on search costs involved in recruiting low wage labor from distant markets.

Mexican migrants to the United States and African migrants to France indicate that this crude form of employer search is still prevalent.¹

Obviously none of the barriers mentioned above apply to migrants between metropolitan areas in the United States. But an incentive for employer search at a distance still remains. Although for a given expenditure more applicants can probably be searched by concentrating search on the local labor market, the return from search depends on the number of acceptances that given search expenditure can achieve. For a given wage offered by the firm, the number of acceptances from given applicants will vary inversely with the expected value of the acceptance wage at a particular location. Even if the number of applications per dollar of expenditure on search is larger at nearby locations, firms will engage in distant search if acceptances per application are sufficiently likely elsewhere. Obviously there is a simultaneous relationship between wages offered and search costs. As it becomes difficult to gain the required number of accessions from the local labor market, firms will raise wages in order to lower search costs and other costs related to turnover rates. Since relative search

¹For a recent example indicating that French employers pay a bounty equivalent to \$300 for each African worker smuggled into France, see: Larrimore, Don M., "Ring Said To Have Smuggled Thousands Into France," The Washington Post, (July, 20, 1972), pg. A21.

costs are important in determining the pattern of worker search effort, it is important to consider possibilities for employer search at a distance in formulating any model of migration.

The assumptions discussed above, and often neglected in analyzing labor market behavior, will have an important effect on the models of migration developed here.

III:3) Model Of Migration And Worker's Job Search

This section will develop a model of migration based on the economics of information, and concerned directly with the worker's labor market choice. First assumptions of the model are reviewed. Then the conditions for optimal search are developed, subject to different assumptions concerning knowledge of wages elsewhere.

The attempt here is to account for job search behavior on the part of homogeneous labor at one location in response to homogeneous job vacancies at a variety of locations. As was discussed in the previous section, workers can engage in offer stockpiling. The time required to search additional opportunities is short compared to the decision time required by employers between initial application and final acceptance. No learning occurs in the search process. Worker perceptions of prevailing wage distributions are not significantly modified as

a result of searching job vacancies at other locations. Also resampling firms at a distance will not be possible. Firms do not maintain a waiting list of applicants, particularly from distant locations, who might be called later when vacancies appear. These basic assumptions were discussed and justified in the previous section.

Search costs vary by residence of the worker and location of the labor market being investigated. Search costs can be written as a function of the number of searches undertaken at that location and the wage or opportunity cost of time at their residence.

$$\text{III:3:1) } c_{ij} = C_{ij}(n_j, w_i)$$

where: c_{ij} = cost per opportunity searched at j by residents of area i ,

n_j = number of searches undertaken at j

w_i = wage or more generally opportunity cost of time at i .

There are a number of other important variables incorporated in the parameters of the c_{ij} function. Possibly the most important of these in terms of the migration literature is the distance between i and j . Also mentioned frequently is the presence of friends and relatives at j . Survey research results suggest the importance of friends and relatives contacts in locating employment both locally and at a distance.

Workers are assumed to allocate their labor services and search activities so as to maximize their wealth, or the rate of return on their human capital, subject to consumption effects mentioned above. The consumption effects, other than relative prices which are embodied in real wages, are embodied in what will be called an attractiveness function.

$$\text{III:3:2)} \quad a_j = A_j(G_{1j}, \dots, G_{kj})$$

where: a_j = a value of attractiveness of area j in terms of dollars per unit time,

$G_{1j} \dots G_{kj}$ = index of each element of attractiveness at j , based on climate, etc.

Because there are large moving or transaction costs associated with migration, the worker is involved in a comparison of flows of earnings at two different locations. The expected value of this income flow confronting a worker in area i and currently receiving a real wage of w_i depends on the time until retirement and the distribution of offered wages.¹ If, for ease of notation, the average time needed to search one job opportunity is used as the basic measure of time, then it is easy to show that a worker may spend the number of time periods remaining until retirement in three ways. First he may work at i and not search any other location. Alternatively workers may be employed or unemployed at i and actively engage in search at other destinations. In this case search costs are

¹Here retirement is equivalent to expected duration of job.

incurred as defined by the C_{ij} function. Thirdly workers may accept a position at another location. Return and repeated migration is an empirical reality. But given transactions costs of moving and the associated change in costs of search upon moving, the migration decision must reflect a long-run commitment to the destination labor market. Thus offer acceptance in a distant labor market indicates that the opportunity found is a permanent alternative to other possibilities. The income-maximizing worker will allocate his employment and search effort among: employment at the origin; job-search; and employment at the destination.

The benefits from search depend on the maximum wage found as a result of search. Assuming that offers can be stockpiled, workers will be concerned with the increase in the expected value of the maximum wage found as a result of an additional job searched. If the cumulative frequency distribution of wages offered in area j is $F_{w_{0j}}(w)$, the probability that the best offer found in n_j searches at j is not greater than w is:

$$\text{III:3:3) } F_{w_{0j}}^M(n_j)(w) = (F_{w_{0j}}(w))^{n_j} = \left(\int_0^w f_{w_{0j}}(w) dw \right)^{n_j}$$

where: $F_{w_{0j}}^M(n_j)(w)$ = cumulative density function of the maximum offered wage found in n_j searches at j ;

$F_{w_{0j}}(w)$ = cumulative frequency distribution of wages offered in area j ;

$f_{w_{0j}}(w)$ = probability density function of offered wages at j .

In III:3:3 the cumulative density function of the new random variable $w_{oj}^M(n_j)$, the maximum offer found in n_j searches is defined as a function of the cumulative density function of offered wages at j . The income-maximizing worker will base his search effort on the expected value of the maximum offer found in n_j searches. In order to evaluate this expected value, it is necessary to differentiate $F_{w_{oj}^M(n_j)}(w)$ to find the probability density function of $w_{oj}^M(n_j)$ with respect to the cumulative and marginal density functions of w_{oj} .

$$\text{III:3:4) } f_{w_{oj}^M(n_j)}(w) = d(F_{w_{oj}}(w))^{n_j} / dw = n_j (F_{w_{oj}}(w))^{(n_j-1)} f_{w_{oj}}(w)$$

where: $f_{w_{oj}^M(n_j)}(w)$ = the probability density function of maximum wages found in n_j searches at j .

Thus the probability density function of maximum offered wages found in n_j searches is a direct function of the number of searches and both the cumulative and marginal density functions of offered wages at j .

The expected value of the maximum offer found after n_j searches, $w_{oj}^M(n_j)$, can be derived in the usual fashion from the probability density function of maximum offered wages.

$$\text{III:3:5) } w_{oj}^M(n_j) = \int_0^\infty n_j w (F_{w_{oj}}(w))^{(n_j-1)} f_{w_{oj}}(w) dw$$

where: $w_{oj}^M(n_j)$ = expected value of maximum offered wages found in n_j searches at j .

The expected value of the increase in the value of the maximum wage found in one additional search effort, dw_{Oj}^M/dn_j , is equal to the difference of $w_{Oj}^M(n_j)$ and $w_{Oj}^M(n_j-1)$. It has been shown that dw_{Oj}^M/dn_j is a decreasing function of n_j so that there are diminishing returns to additional search.¹ This is a general result in the economics of information.

If offer stockpiling is not possible, the benefit from further search is equal to the difference between present wages or an immediate job offer in hand and the mean of the offered wage distribution.²

The functions which have been developed thus far can be combined to formulate an expression for the expected value of the real income or wealth of workers at a particular location. Consider first the simple case in which a worker in area i is employed at wage w_i with T time periods until retirement, or time horizon for employment decisions equal to T , and has only an opportunity for search in destination j . The real wealth of such workers is based on present earning possibilities plus the value of the opportunity to search distant labor

¹ Proof that the expected value of the maximum of a random sample of n observations increases with n at a decreasing rate follows from a result provided by Robert Solow and presented in: Stigler, George, "The Economics Of Information," Journal of Political Economy, (June, 1961), pg. 215.

² The assumption that offer stockpiling is not possible has received little or no empirical justification in such job-search models. Indeed the issue of stockpiling is often not considered. The model presented here will follow the literature in assuming that stockpiling is not possible.

markets.

$$\text{III:3:6) } E(Y_1) = (w_{oj}^M(n_j) + a_j)(T - n_j) - (n_j)C_{ij}(n_j, w_1) + n_j(w_1 + a_1) - K_j$$

where: $E(Y_1)$ = expected value of income stream available to worker employed in area i at wage w_1

K_j = moving cost from area i to area j

Moving cost, or K_j , the only function not discussed previously, may be a function of wages. If so, it would appear to be an increasing function of wages. Equation III:3:6 assumes that workers at i have complete knowledge of the distribution of wages at j . The formulation in III:3:6 indicates that the number of searches at j is the basic decision variable for the potential migrant. This approach is taken in order to examine the extent and pattern of search activity on the part of workers. Survey evidence indicates that migrants adopt acceptance wages rather than engaging in a given degree of search and then accepting the highest offer found. There is a basic symmetry between the two approaches. $w_{oj}^M(n_j)$ is the expected value of the maximum offer found in n_j searches. Thus if $w_{oj}^M(n_j)$ is adopted as the acceptance wage, then the expected value of the number of searches is n_j . In III:3:6 adoption of $w_{oj}^M(n_j)$ as the acceptance wage for an offer from j will yield an expected value of income to the worker of Y_1 .

¹ $E(Y_1)$ is the expected value of the gain from search less costs of search and moving costs plus income from present employment. This relationship is common in job-search models.

The wealth-maximizing worker will make search, work, and migration decisions such that Y_1 , or more precisely its expected value, $E(Y_1)$, is maximized. Necessary conditions for a maximum of $E(Y_1)$ indicate the determinants of decisions on work vs search vs migration in any time period. The worker's status with respect to these three activities is completely described by the n_j chosen by the worker. Thus choice of n_j equal to 6 reflects a determination to search for that many time periods followed by migration if a sufficiently attractive offer is found. In equation III:3:6, n_j is the basic decision variable confronting the worker. The necessary condition for a maximum of income can be found by differentiating III:3:6 with respect to n_j . For ease of exposition, a total search cost function, $C_{1j}^*(n_j, w_1)$, will be substituted for the total cost expression in equation III:3:6, $n_j C_{1j}(n_j, w_1)$, in the computation of the total differential of $E(Y_1)$ with respect to n_j shown below.

III:3:7) $dE(Y_1)/dn_j = (w_1 + a_1) - (w_{0j}^M + a_j) + (T - n_j)dw_{0j}^M/dn_j - \partial C_{1j}^*/\partial n_j$
 A necessary condition for a maximum of $E(Y_1)$ is that $dE(Y_1)/dn_j$ be equal to zero. In equation III:3:7, setting $dE(Y_1)/dn_j$ equal to zero and rearranging terms gives an expression which equates marginal benefits from search with marginal costs of additional search.

$$\text{III:3:8) } \partial C_{ij}^* / \partial n_j + [(w_{oj}^M + a_j) - (w_i + a_i)] = (T - n_j) \partial w_{oj}^M / \partial n_j$$

The expression on the left hand side of III:3:8 is the expected value of the marginal cost of another opportunity searched. This cost consists of two components: $\partial C_{ij}^* / \partial n_j$ is the marginal out of pocket plus time cost of search; $(w_{oj}^M + a_j) - (w_i + a_i)$ is the difference between the expected value of the best offer received at j and current earnings at i . The latter component of costs represents the opportunity cost of delaying acceptance of the previous best offer. The right hand side of III:3:8 represents the increase in expected earnings due to an additional search weighted by the time remaining on the job.

Equation III:3:8 indicates that, as a precondition for any search at j , $(T-1) \partial w_{oj}^M / \partial n_j$ must exceed the cost of an initial search plus any net difference in attractiveness, $a_i - a_j$. This is a second implication of the necessary conditions for a maximum of $E(Y_i)$.

Second order conditions for a maximum of $E(Y_i)$ require that the derivative of III:3:7 with respect to n_j be less than zero.

$$\text{III:3:9) } d^2 E(Y_i) / dn_j^2 = -2(\partial w_{oj}^M / \partial n_j) + (T - n_j) d^2 w_{oj}^M / dn_j^2 - \partial^2 C_{ij}^* / \partial n_j^2$$

Some a priori information is available and has been presented on the signs of the terms in III:3:9. Equations III:3:4 and III:3:5 demonstrated that $\partial w_{oj}^M / \partial n_j$ was greater than zero while

they also indicate that $d^2 w_{oj}^M / dn_j^2$ is negative. Similarly it was previously established that survey research results and job-search models generally suggest that $d^2 c_{ij}^* / dn_j^2$ is negative. Thus, given assumptions about the signs of various terms of III:3:9 made above, second order conditions for a maximum of $E(Y_i)$ require that the relationship shown below hold.

$$\text{III:3:10) } 2(dw_{oj}^M / dn_j) - (T - n_j)d^2 w_{oj}^M / dn_j^2 > -d^2 c_{ij}^* / dn_j^2$$

The left hand side of III:3:10 is the rate of change in the marginal benefit from search while the right hand side is the rate of change with additional search of the total marginal cost of search including foregone wage offers already received. The rate of decrease in marginal benefit with additional search must exceed the rate of decrease in marginal search costs.

The analysis developed thus far can be extended to include the possibility of search in a number of labor markets, each with its own wage distribution. Workers are initially located in area i , which is one of k labor market areas. In this case individuals have a choice of continued work at i without search, search in any one of the k market areas, or migration to one of the $k-1$ destinations. Worker activity in these three possible pursuits is described by the extent of search effort in each of the labor markets.

The first step in determining the pattern of worker search effort and related characteristics of the migration decision is to find the expected value of the income stream available to a worker at i .

$$\text{III:3:11) } E(Y_i) = \sum_{j=1}^k (w_{oj}^M(n_j) + a_j)(T-n) - C_{ij}^*(n_j, w_i) + n(w_i + a_i) - K_j$$

$$\text{where: } n = \sum_{j=1}^k n_j$$

This expression incorporates the possibility of search in the local labor market at i as well as elsewhere.

Necessary conditions for maximum income are again found by differentiating by the decision variables, $n_1, \dots, n_j, \dots, n_k$.

$$\text{III:3:12) } dE(Y_i)/dn_j = (T-n)dw_{oj}^M/dn_j - \sum_{j=1}^k (w_{oj}^M + a_j) - \partial C_{ij}^*/\partial n_j + (w_i + a_i)$$

A necessary condition for a maximum of $E(Y_i)$ is that $dE(Y_i)/dn_j$ be equal to zero for all $j = 1, \dots, k$. In equation III:3:12, setting $dE(Y_i)/dn_j$ equal to zero for all j and rearranging terms gives an expression which equates marginal benefits from search with marginal costs of additional search.

$$\text{III:3:13) } (T-n)dw_{oj}^M/dn_j = \partial C_{ij}^*/\partial n_j + \sum_{j=1}^k (w_{oj}^M + a_j) - (w_i + a_i)$$

Marginal benefits are on the right hand side of equation III:3:13 and costs on the left hand side of the equation include opportunity costs of forgone wages in the best offer received previously compared to earnings in area i .

A second result arising from the necessary conditions

derived above is that the ratio of the expected value of benefits to out of pocket search costs is the same for all locations.

$$\text{III:3:14)} \quad \frac{(T-n)dW_{oj}^M/dn_j}{\partial C_{ij}^*/\partial n_j} = \frac{(T-n)dW_{ol}^M/dn_l}{\partial C_{il}^*/\partial n_l} = \frac{(T-n)dW_{ok}^M/dn_k}{\partial C_{ik}^*/\partial n_k}$$

Equation III:3:14 suggests the basic conditions for partitioning search among alternative locations. If a location is to be searched at all, the ratio of the increase in the expected value of the maximum wage offer found at that location to marginal out of pocket search costs must equal the ratio at other locations searched. Thus the increase in expected value of maximum offered wages found per dollar of out of pocket search cost must be equal at all locations searched.

The decision rule for migration and job search implied by III:3:12 to III:3:14 involves conducting n searches while continuing employment at i . Searches are distributed among the k destinations to satisfy the first order conditions in III:3:14. The worker will then accept the offer whose $w_j + a_j$ is largest. An alternate decision rule involves establishing a reservation or acceptance wage. In the case of the model developed above, the reservation wage is equivalent to the expected value of the maximum wage and attractiveness combination found in n searches. Thus the reservation wage which

would be consistent with this search model is based on a weighted index of offered wage distributions elsewhere. The weights are a function of the degree of search in each labor market.

Another possibility for worker search is the absence of significant information on wage distributions elsewhere. In this case, there may be a tendency to assume that wages offered at a number of alternative locations are identical. Such limited knowledge requires little modification of the model which was developed for the case of perfect information. There was no presumption in equation III:3:12 that the w_{oj}^M functions were accurate or even that they were not identical. However, if all offered wage distributions are identical - perhaps believed to be the same as those at i - the a priori results developed on the basis of first order conditions are subject to more concrete interpretation. For example, in equation III:3:14, if offered wage distributions are identical, the number of searches in each area actually searched depends only on the shape of the C_{ij}^* functions.

Second order conditions for a maximum of real income require that $d^2E(Y_i)/dn_j^2$ is less than zero. As was the case when search at one alternate destination was considered, these conditions require the rate of decrease in the expected value

of the maximum offer found at a given location exceed the rate of decrease in total costs of search including foregone earnings in the best position previously found.

$$\text{III:3:15) } -(T-n)d^2w_{oj}^M/dn_j^2 > \partial^2 c_{ij}^*/\partial n_j^2 + dw_{oj}^M/dn_j + \sum_{j=1}^k dw_{oj}^M/dn_j$$

The right hand side of III:3:15 is the rate of change with additional search of the total marginal cost of search including foregone wage offers already received. The left hand side of this inequality reflects the rate of change of the expected value of the best offer found.

The results presented thus far illustrate the rationale for search at a number of alternative locations preceeding migration. The number and pattern of locations searched depend on characteristics of search costs and the extent of knowledge of opportunities elsewhere.

IV, 1) Recruiting Efforts By Employers

Survey responses of migrants reviewed in Chapter II:3 indicate that search efforts on the part of employers are important in providing information needed for or by migrants. But a substantial portion of job-search literature and also the human capital models of migration neglect employer-financed search entirely. The rationale for this omission has been that there is no economic return to employer search

outside the local labor market. Workers, who are induced to move to a distant labor market, will quickly adjust to prevailing wages at the destination.

Even if workers quickly adjust to local wages or local restrictions and labor contracts fix wage levels for workers of given skill, there remain positive returns to search by firms. Changing labor force requirements and separations, both anticipated and unanticipated, imply that firms must secure a flow of new workers. These accessions come from recalls and new hires based on applications for positions vacant. Search effort by the firm can increase the flow of applications received. The fraction of acceptances from applications received depends on the probability that offered wages are above the reservation wage of applicants. This probability will be termed the offer acceptance probability. While searching distant labor markets may be more expensive than local search for employers, offer acceptance probability may be higher at a given wage offer in areas where reservation wages are lower. This is the source of returns to employer search.

The remainder of this section will develop a simple model of the extent and distribution of employer search activity in a system of labor markets. First firms at a particular location can define a loss function related to vacancies. In an abstract sense, such a loss function could be viewed as the value of the marginal physical product of labor given differences in the size of the workforce. The number of separations

is assumed to be forecast with certainty along with demand for firm output. This means that the value of the marginal physical product of labor can be determined and losses as a function of vacancies unfilled can be represented for a firm located in area j by $L_j(v_j)$.¹ For the firm $L_j(v_j)$ will be the difference between the prevailing level of offered wages, which are only adjusted infrequently, and the value of the marginal physical product of labor.

Optimal personnel policy for the firm described above involves allocating funds to labor recruitment so that the sum of $L_j(v_j)$ and recruiting costs is a minimum. Firms may search at any one of k locations. They may recruit applicants in various areas according to the simple cost function below.

$$\text{III:4:1)} \quad r_{ij} = R_{ij}(x_i)$$

where: r_{ij} = total cost of recruiting applicants

x_i = number of applicants recruited from area i .

Probably the most important constant embodied in R_{ij} is distance from the firm to area i , size of i may be important.

Applicants can only be translated into vacancies filled through a process of determining their abilities and finally

¹For an individual firm $L_j(v_j)$ depends on the price of output, prices of variable inputs other than labor, present size of the labor force less voluntary separations, and the amounts of fixed factors in place.

assessing their inclination to accept the offered wages attached to their skill levels by the firm. The analysis of worker behavior in the previous section established that, if firms make search sufficiently inexpensive and workers do not believe that wages in the area are very low, workers will allocate some search effort to the area in which the firms are located. However, workers will generally search other areas also. Unless wages offered by firms are higher than other offers found by workers in their n searches, the results of the last section indicate that acceptances will comprise a small fraction of applicants. Alternatively, if workers formulate an acceptance wage, based on the expected value of maximum wages found in the number of searches undertaken, the offered wage must be equal to or greater than this acceptance wage. For given offered wages by the firm, the expected value of the fraction of acceptances gained from applicants from a particular labor market is a decreasing function of the reservation wage in the area.¹

$$\text{III:4:2)} \quad p_{ij} = P_{ij}(w_{ai}, w_{oj}, a_i, a_j)$$

where: p_{ij} = the probability that an acceptance wage at i is below or equal to the offered wage at j .

w_{ai} = index of acceptance wage at i

w_{oj} = offered wage of firm at j .

¹The reservation wage is stochastic depending on the distribution of search costs and wage perceptions of workers at i .

a_i and a_j = real income equivalent of amenity
or attractiveness at i and j .

Firms will attempt to follow a recruiting policy that minimizes the sum of losses due to unfilled vacancies and costs of attracting applicants.

$$\text{III:4:3) } C_j = L_j(v_j) + \sum_{i=1}^k R_{ij}(x_i)$$

where: C_j = the total cost of having v_j unfilled vacancies and attracting x_i applicants from $i = 1, \dots, k$ areas.

The number of vacancies filled is equal to the summation over all areas searched of applicants found multiplied by the appropriate offer acceptance probability.

$$\text{III:4:4) } v_j = v_j^* - \sum_{i=1}^k x_i P_{ij}(w_{ai}, w_{oj}, a_i, a_j)$$

where: v_j^* = the number of additional workers that can be added at wages of w_{oj} before L_j falls to zero.

Optimal search policy involves minimization of C_j subject to the possibility that applicants may reject the offered wage.

$$\text{III:4:5) } C_j^* = L_j(v_j) + \sum_{i=1}^k R_{ij}(x_i) - \lambda [v_j^* - v_j - \sum_{i=1}^k x_i P_{ij}(w_{ai}, w_{oj}, a_i, a_j)]$$

where: λ = an undetermined multiplier.

First order conditions for a minimum of C_j and C_j^* require search to be distributed so that the expected value of the marginal search cost required to recruit an additional worker who will accept the position is the same at all location and

further that this marginal cost is equal to the marginal loss due to an additional unfilled vacancy.

$$\text{III:4:6) } dL_j/dv_j = dR_{ij}/dx_j(P_{ij}(w_{ai}, w_{oj}, a_i, a_j))^{-1}$$

Equation III:4:5 must hold for all areas $i = 1 \dots k$. Thus firms will engage in attempts to recruit workers outside the local labor market. In general they can be expected to search areas that are not far away and have labor market mechanisms which facilitate search for applicants. Firm search will also concentrate in areas where wages and perceived wage distributions or levels of amenity are low relative to wages offered and attractiveness available at the site of the firm.

Nothing in this section establishes recruiting applicants at a distance as a major economic activity. But both survey evidence and the results of the previous section suggest that relative search costs can have a significant effect on the pattern of job offers investigated by workers at a particular location. The potential impact of such firm search is heightened if recruiters exaggerate the attractiveness and opportunities associated with particular destinations. Thus the potential impact of such recruiting is greatest when workers are ignorant of conditions elsewhere.

III:5) A Job-Search Model Of Migration Flows

This section develops a model of the movement of a homogeneous work force among labor market areas. Emphasis is placed on the response of workers to earning opportunities at alternative destinations. First notion of an acceptance wage developed in III:3 is extended to labor market decisions which require choice among alternative locations. Then offer acceptance probability is defined in terms of the joint probability distributions of origin acceptance wages and destination offered wages. Finally equations describing migration flows between areas are developed.

Workers in area i formulate reservation or acceptance wages based on their perception of wages, attractiveness of various areas, and costs of job search. If workers have perfect knowledge of wages and amenities at prospective destination j , direct application of III:3:7 suggests that the acceptance wage can be interpreted in terms of the expected value of maximum wages found in the number of searches that maximizes income. Thus equation III:3:7 can be rewritten with the expected value of the maximum offer found now set equal to the acceptance wage, W_{aij} , of workers at i for offers from area j .

III:5:1) $W_{aij} = W_{oj}^M = w_i + (a_i - a_j) + (T - n_j) dw_{oj}^M / dn_j - \partial C_{ij}^* / \partial n_j$
 where: W_{aij} = acceptance wage of workers at i for offers from area j

n_j = number of searches such that income is maximized for worker at i with wage w_i .

other variables are as defined in Chapter III sections 3 and 4.

An equation such as W_{aij} creates both analytic and empirical difficulties. First III:5:1 implies that workers at i have a different acceptance wage for each destination j, depending on a_j , n_j , C_{ij}^* , w_{oj} . But we know from III:3:8 that the number of searches allocated to each area is determined by the point at which the expected value of the increase in the maximum offer found is equal to marginal search costs, including opportunity costs of past offers forgone. Thus for each area actually searched, the difference of $(T - n_j) dw_{oj}^M / dn_j$ and $\partial C_{ij}^* / \partial n_j$ is set equal to the same opportunity cost... This implies an additional analytically complex relationship among acceptance wages at different locations. In a system of many areas with perfect knowledge of offers elsewhere, W_{aij} will depend on the entire structure of offered wages. In addition to the analytical complexity involved in models based on the assumption of perfect information, there are empirical contradictions involved in such suppositions. The survey research results reviewed in Chapter II indicate that worker

perceptions of opportunities elsewhere are neither accurate or precise. Indeed Parnes found that workers in low-wage firms believed their wages were higher than average.¹ This explains their continued employment in low-wage firms.

An alternate assumption, which has the advantage of agreement with survey results, is that workers believe that wages elsewhere are similar to those at the origin. In this case III:5:1 can be rewritten in terms of the distribution of wages at the origin.

$$\text{III:5:2) } w_{aij} = w_i + (a_i - a_j) + (T - n_j) dw_{oi}^M / dn - \partial C_{ij}^* / \partial n$$

Thus the acceptance wage of workers in area i applicable to offers from area j depends on amenity in area j, a_j , and amenity and wages in area i.

Once an acceptance wage has been defined for each destination, search proceeds until an offer which equals or exceeds the acceptance wage is found. Of course, at any time many workers may not find search profitable. This is particularly true for workers whose present wages are near the high end of the offered wage distribution.

Equation III:5:2 indicates that the acceptance wage of a worker at i is an increasing function of w_i . Thus even if all workers in an area assess amenity factors similarly, and face the same search costs with identical perceptions of the

offered wage distribution at i , the acceptance wage at i will be a random variable, depending on the actual distribution of wages at i . Thus the new random variable, acceptance wage at i for offers from j , may be expressed in terms of III:5:2.

$$\text{III:5:3)} \quad w_{aij} = w_i^* + (a_i - a_j) + (T - n_j) dw_{oi}^M / dn - \partial C_{ij}^* / \partial n$$

where: w_i^* is a random variable reflecting the distribution of wages at i .

Given assumed values for a_i , a_j , $C_{ij}^*(n)$, and the distribution function of w_i^* , ($f_{w_i^*}(w)$), it is possible to evaluate the marginal probability distribution function of w_{aij} , $f_{w_{aij}}(w_a)$. This function will have a non-zero value for w_a equal to or slightly less than the minimum wage to maximum wage levels found in the area.

The acceptance wage w_{aij} at i and offered wages at j , w_{oj} , are independently distributed. Thus the joint probability density function of w_{aij} and w_{oj} is equal to the product of the marginal probability density functions.

$$\text{III:5:4)} \quad f_{w_{aij}, w_{oj}}(w_a, w_o) = f_{w_{aij}}(w_a) f_{w_{oj}}(w_o)$$

Since offer acceptance follows automatically upon location of an offer above the acceptance wage, it is necessary to define a new random variable z_{ij} equal to the difference of offered and acceptance wages.

$$\text{III:5:5)} \quad z_{ij} = (w_{oj} - w_{aij})$$

Obviously the offer acceptance probability for a particular origin-destination pair is the probability that z_{ij} equals or exceeds 0. Evaluating this probability requires solution for the cumulative distribution function of z_{ij} in terms of the probability density functions of w_{aij} and w_{oj} . This is accomplished by integrating the joint probability density function III:5:4 over the relevant region, from 0 to the maximum wage.

$$\text{III:5:6)} \quad P_{aij} = F_{z_{ij}}(z) = \int_0^{\infty} f_{w_{aij}w_{oj}}(w_a, w_o) dz$$

where: P_{aij} = offer acceptance probability between areas i and j = $\text{Prob}(0 \leq z_{ij} \leq z)$

As with the solution for the derived distribution $f_{w_{aij}}(w_a)$, explicit formulation of P_{aij} as a function of offered wages at i and j depends on the actual distribution of wages at i, $f_{w_{oi}}(w)$, and j, $f_{w_{oj}}(w_o)$. Exact specification of functional forms must wait upon the assumption or empirical determination of these distributions.

In addition to the offer acceptance probability, the number of migrants between two areas depends on the degree of search effort expended by workers from i in area j and the number of potential migrants. Thus if search effort is expressed in terms of the number of searches in area j per time period per potential migrant from area i, an aggregate

migration function can be written.

$$\text{III:5:7) } M_{ij} = P_{aij} P_i S_{ij}$$

where: M_{ij} = migrants from i to j

P_i = potential migrants in area i

S_{ij} = number of searches per year per potential migrant at i in area j

The function S_{ij} , number of searches per year per potential migrant at i in area j , depends on the number of searches per migrant per time period defined in III:3:4 and on the distribution of searches across areas.

The distribution of search effort across metropolitan areas is the critical part of S_{ij} thus far left unexplored. This can be remedied by expanding the model of the income-maximizing worker developed in III:3:6 to consider search among many labor market areas $j = 1, \dots, k$. The worker maximizes income by choosing a pattern of search in the k areas, $n_1, \dots, n_j, \dots, n_k$, such that the expected value of income is maximized.

$$\text{III:5:7) } E(Y_1) = \sum_{j=1}^k (w_{oj}^M(n_j) + a_j)(T - n_s) - C_{ij}^*(n_j, w_1) + n_s(w_1 + a_i) - K_j$$

subject to: $n_s = \sum_{j=1}^k n_j$

where: n_s = total searches undertaken at all locations.

First order conditions for a maximum of income require that, for all areas j , search effort n_j be allocated in the following manner.

$$\text{III:5:8) } dE(Y_i)/dn_j = (w_i - w_{oj}^M) + (a_i - a_j) + (T - n_s)dw_{oj}^M/dn_j - \partial C_{ij}^*/\partial n_j = 0$$

If, as we have assumed in this section and survey research indicates, perceived wage distributions elsewhere are similar to those at home, then the necessary condition for a maximum of income can be written in terms of search costs and attractiveness at alternative locations.

$$\text{III:5:9) } (a_j - a_1) = (\partial C_{i1}^*/\partial n_1) - (\partial C_{ij}^*/\partial n_j)$$

The fraction of search effort allocated to a particular destination varies directly with attractiveness and inversely with search cost.

Unfortunately it is difficult to develop a priori information on the shape and determinants of the C_{ij}^* function. Survey research results suggest that friends and relatives linkages as well as employer-borne search costs are both important elements of C_{ij}^* . Since workers are likely to have relatives and/or firends in only a small number of alternative areas, search costs for individuals may be far lower in one or two areas. This is reinforced by the survey research result finding that workers consider few alternative destinations. In III:4 firms in the highest wage areas

were shown to realize a return from investing in employee search in low-wage areas. Once again this suggests that search costs in a few destinations will be lower than others. In this case high-wage areas would have the lowest costs.

Chapter IV

AGGREGATION AND SIMULTANEOUS EQUATION PROBLEMS IN THE SPECIFICATION OF MIGRATION EQUATIONS

This chapter relaxes the assumption that population is homogeneous. Given the results of differential migration studies, there is reason to suspect that migration between two areas depends in part on the detailed characteristics of population in each area. The conditions for consistent aggregation of migration functions are examined. Secondly the simultaneous relationship between wage rates and population flows is modeled. Finally the interaction between aggregation and simultaneous equation problems is explored. Limits on the ability to estimate simultaneous equation models of migration and wage changes given present data sources are developed.

IV:1) The Problem of Consistent Aggregation

The aggregation problem arises out of differential migration rates characteristic of various age, sex, skill, and occupation categories. The extensive literature on differential migration was reviewed in Chapter I.

Unfortunately there are no data series on migrants by the four categories mentioned most in the differential migration literature.¹ Only the survey literature provides

¹Social Security records omit occupation and education data.

a source of individual record data by detailed demographic categories. Thus there is a basic need to deal with aggregate migration functions.

In the case of migration functions developed above, acute aggregation problems reside in the offer acceptance probability function. These will be demonstrated in terms of a simple model.

Consider the offer-acceptance probability to depend on two categories of variables. The first variable will be called a wage and is specific to a single demographic group: age; sex; occupation; and education category. The second variable will be termed an environmental or public good variable because it represents attributes of an area that affect all residents of the locality equally. Notable examples are price indexes, environmental quality, public goods, climate, etc.

Now the offer acceptance probability for migration between origin i and destination j will depend on the wage variables w_i^k and w_j^k characteristic of demographic group $k = 1, 2, \dots, m$. We have suggested that the wage at each location will generally be a stochastic variable but for this discussion may be regarded as deterministic. The single environmental or public good variable of interest for areas i and j will be G_i and G_j .

The individual offer acceptance probabilities for each of the m demographic groups, $p_{aij}^1, \dots, p_{aij}^k, \dots, p_{aij}^m$, may be expressed in terms of the notation developed above as:

$$\begin{aligned} \text{IV:1:1)} \quad p_{aij}^1 &= p_{aij}^1(w_i^1, G_i, w_j^1, G_j) \\ p_{aij}^k &= p_{aij}^k(w_i^k, G_i, w_j^k, G_j) \\ p_{aij}^m &= p_{aij}^m(w_i^m, G_i, w_j^m, G_j) \end{aligned}$$

The problem of consistent aggregation involves finding the following three functions:

$$\begin{aligned} \text{IV:1:2)} \quad A_{W_i}(w_i^1, w_i^2, \dots, w_i^k, \dots, w_i^m) &= w_i^T \\ \text{IV:1:3)} \quad A_{W_j}(w_j^1, w_j^2, \dots, w_j^k, \dots, w_j^m) &= w_j^T \\ \text{IV:1:4)} \quad A_{P_{aij}}(p_{aij}^1, \dots, p_{aij}^k, \dots, p_{aij}^m) &= p_{aij}^T \end{aligned}$$

Where IV:1:2 through IV:1:4 are chosen such that an aggregate migration function may be written in terms that sacrifice none of the behavioral results contained in the original functions, giving:

$$\text{IV:1:5)} \quad p_{aij}^T = A_{P_{aij}}(w_i^T, G_i, w_j^T, G_j)$$

Aggregate migration functions require that the existence and functional form of A_{W_i} , A_{W_j} , and $A_{P_{aij}}$ be demonstrated on the basis of a priori information arising from behavioral assumptions of the migration model.¹ The conditions for consistent aggregation may require making strong and restrictive assumptions about the behavior of migrants.

¹The discussion of migration presented here relies on an extensive literature on aggregation problems developed in other contexts.

There are strong a priori restrictions on the form of the A_{paij} function. Aggregate acceptance probability depends on the acceptance probability of each individual demographic group weighted according to the fraction of total origin population in that demographic category.

$$\text{IV:1:6)} \quad p_{aij}^T = \sum_{k=1}^m p_{aij}^k N_1^k / N_1$$

where: N_1 = total population at the origin

N_1^k = the number of type k individuals at the origin.

This is the form of the A_{paij} function which is implied by the use of offer acceptance probability within the job-search model of migration developed in the previous chapter.

Aggregate wage indexes for states and metropolitan areas generally assume the form:

$$\text{IV:1:7)} \quad w_1^T = \sum_{k=1}^m w_1^k E_1^k N_1^k / N_1$$

$$\text{IV:1:8)} \quad w_j^T = \sum_{k=1}^m w_j^k E_j^k N_j^k / N_j$$

where: E_1^k = the fraction of demographic group k actually employed in area i

E_j^k = the fraction of demographic group k actually employed in area j .

The E_1^k and E_j^k terms function as weights indicating the participation of each demographic group in the activity to which the wage variables, w_1^k and w_j^k , refer. In this case the activity is measured employment.

Now that specific functional forms have been specified for A_{w_1} , A_{w_j} , and $A_{p_{aij}}$, necessary conditions for the existence of an aggregate migration function based on these aggregating functions may be derived. Consistent aggregation requires that, for any change in the w_1^k or w_j^k variables that leaves A_{w_1} and A_{w_j} unchanged, in equation IV:1:5, p_{aij}^T must also be unchanged. There are six different categories of necessary conditions.

$$\text{IV:1:9)} \quad \partial p_{aij}^T / \partial w_1^T = \partial p_{aij}^k / \partial w_1^k \quad \text{for all } k = 1 \dots m$$

$$\text{IV:1:10)} \quad \partial p_{aij}^T / \partial w_j^T = \partial p_{aij}^k / \partial w_j^k \quad \text{for all } k = 1 \dots m$$

$$\text{IV:1:11)} \quad \partial p_{aij}^T / \partial G_1 = \partial p_{aij}^k / \partial G_1 \quad \text{for all } k = 1 \dots m$$

$$\text{IV:1:12)} \quad \partial p_{aij}^T / \partial G_j = \partial p_{aij}^k / \partial G_j \quad \text{for all } k = 1 \dots m$$

$$\text{IV:1:13)} \quad E_1^1 = E_1^k \quad \text{for all } k = 2 \dots m$$

$$E_j^1 = E_j^k \quad \text{for all } k = 2 \dots m$$

$$\text{IV:1:14)} \quad N_1^k / N_1 = N_j^k / N_j \quad \text{for all } k = 1 \dots m$$

The job-search models developed in the previous chapter suggest that the functions $\partial p_{aij}^k / \partial w_1^k$, $\partial p_{aij}^k / \partial w_j^k$, $\partial p_{aij}^k / \partial G_1$, and $\partial p_{aij}^k / \partial G_j$ are not only not constants but indeed that they are non-linear in many cases. Obviously further conditions connecting the values taken on by w_1^k , w_j^k , G_1^k , and G_j^k are necessary if conditions IV:1:9 through IV:1:12 are to be satisfied.

Condition IV:1:13 requires that the participation rates, E_1^k and E_j^k , be the same for all demographic groups in each

area. If the wage variables are considered to refer only to hourly earnings of employees then this condition requires equal employment rates for all demographic groups. Here the employment rate, the fraction of the group actually employed, functions as the participation rate. As long as the groups considered consist only of "prime age" males, 25 to 64 years of age, this assumption may approximate reality. Clearly the assumption is not valid for the population in general. Indeed the literature surveyed earlier suggested that even among "prime age" males the ratio of white to non-white unemployment rates is not only not equal to one everywhere but that it also varies systematically across geographic areas.¹

The final condition for consistent aggregation, IV:1:14, requires that the population composition at both the origin and destination be identical. This is most unlikely. Fortunately this condition is the simple product of the manner in which the aggregate destination wage was computed. Thus if the same weights are used for A_{W_j} as for A_{W_1} as shown in IV:1:15 below, the last condition for consistent aggregation will be satisfied.

$$\text{IV:1:15)} \quad W_j^T = \sum_{k=1}^m W_j^k E_j^k N_j^k / N_j$$

Similarly the most obvious mechanism for dealing with differences in participation rates among demographic groups

¹See, for example: Rapping, L.A., Unionism, Migration and the Male Nonwhite-White Unemployment Differential, Southern Economic Journal, Vol. 32, No. 3, (July, 1966), pp. 317-329.

is to compute the A_{W_1} and A_{W_j} based on the assumption that the participation rates E_1^k and E_j^k are uniformly equal to one.

Given these modifications in A_{W_1} and A_{W_j} designed to deal with conditions IV:1:13 and IV:1:14, strong questions concerning whether conditions IV:1:9 through IV:1:12 remain. To the extent that these questions involve empirical issues they will be discussed in subsequent sections.

IV:2) Determinants Of Differential Migration

The extensive literature on differential migration suggests that rates of migration vary by age, sex, race, occupation, and education. Such results cannot be taken as positive evidence that the partial response of different demographic groups to given incentives for migration varies systematically. Indeed these studies do not consider the possibility that differential migration may be due to differences in the incentive to migration for each group. Thus the demand side of the labor market is virtually ignored.

This section will attempt to determine the fraction of total migration differentials which is related to differences in mobility among demographic groups, adjusted for demand side effects. The basic rationale for the existence of pure differences in the migratory response of different

groups to equal incentives is based on selective attraction of a fixed residence. Age, and education would seem to be particularly related to the apparent sluggishness or ease with which groups respond to given opportunities for migration. Specifically it might be expected that older and less well educated individuals would be reluctant to change residence.¹

In the tables below the relative propensities of various demographic groups to migrate between metropolitan areas is compared with the relative fractions of the same groups to change their place of residence within the area. This second figure should reflect the attitude of the various groups toward changes in residence in general. As might be expected, there are systematic differences in the fraction of various groups which change residence within metropolitan areas that parallel observed behavior of migrants. However only a fraction of differential migration rates is related to the differences within areas. Residual differences in the propensity to migrate that remain can be attributed to a muddled combination of "pure" differences in incentives to migrate including the preferences of employers and the availability of information on opportunities elsewhere.

Table IV:2:1 below presents the relationship between intra-metropolitan and inter-metropolitan mobility rates for

¹Also monetary and psychic costs of moving may vary by family type and family size in particular.

population cohorts stratified by age.

TABLE IV:2:1) Mobility Of Different Age Groups

Age	Relative Mobility: Intra-Metropolitan (Mobility of Those 65+ Used As Numeraire)	Relative Migration: Inter-Metropolitan
15-19	1.5	3.5
20-24	4.3	6.8
25-29	3.2	7.7
30-34	2.7	4.8
35-44	2.0	3.2
45-54	1.5	1.9
55-64	1.2	1.2
65+	1.0	1.0

Similarly Table IV:1:2 below illustrates the relationship between intra-metropolitan and inter-metropolitan mobility rates for population groups stratified by education.

TABLE IV:2:2) Mobility Of Different Education Groups

Education	Relative Mobility: Intra-Metropolitan (Mobility of Elementary Only Used As Numeraire)	Relative Migration: Inter-Metropolitan
Elementary Less Than 8 Yrs.	1.0	1.0
8 Years Only	1.0	1.2
High School 1-3 Years	1.2	1.7
4 Years Only	1.3	2.3
College 1-3 Years	1.4	3.5
4 Years Only	1.5	7.2

The source of data for both tables above is the 1960 Census of Population.¹ Age and education are the two principal a priori sources of differences in the willingness of individuals to move. For both the age and education variables the indicated intra and inter-metropolitan mobility patterns are closely related. For "prime age" males the rank order of mobility rates is identical within and between areas. This simple test indicates that perhaps half of observed differential migration rates for age cohorts may arise from differences in the "pure" reluctance to change residential location. For education cohorts, increasing educational attainment is related positively to increasing mobility both within and between areas. Much of the difference in mobility by age and education is due to preferences of employers and job rights accrued by older, blue-collar workers. But these factors should affect both differential mobility within and between cities. However, intra-metropolitan mobility differentials account for only a small fraction of the very high differential migration rates based on age and education. Thus the propensity to migrate in the face of given opportunities is related to age and education. Unfortunately data on characteristics of migrants

¹ Data are based on a sample of movers within the population of 15 SMSA's chosen randomly from: U.S. Bureau of the Census, Mobility For States And Metropolitan Areas, PC(2)-2B, Washington, D.C.: U.S. Government Printing Office, (1963)

between metropolitan areas and within them by both age and education characteristics was not found.

The inquiry in this section was motivated by the necessary conditions for consistent aggregation, particularly the first four conditions which required that $\partial p_{aij}^k / \partial w_1^k$, $\partial p_{aij}^k / \partial w_j^k$, $\partial p_{aij}^k / \partial G_1$, and $\partial p_{aij}^k / \partial G_j$ be equal for all demographic groups k .¹ The results suggest that, particularly for groups representing different age cohorts, such assumptions of equal marginal response to changes in wages or general attractiveness at the origin or destination are not supported by empirical evidence.

IV.3) A Simple Model Of The Simultaneous Equation Problem

Migration equations are part of the fundamental growth equations for a metropolitan area. Some of the variables proposed above as arguments of the migration equations are also endogenous to comprehensive models of metropolitan development. This is particularly true of wages. There is a danger of simultaneous equation bias in attempting to estimate the parameters of a migration equation when current values of endogeneous variables are included in the equation.

This section develops a simple aggregate model of metropolitan development that illustrates the nature of simultaneous equation bias that might accompany use of wage variables in a migration equation. Recently there have been

¹ Obviously a more comprehensive data base is needed to quantify these partial derivatives exactly.

some efforts to develop simultaneous equation models of migration and metropolitan growth.¹ None of these efforts has resulted in a full structural model and one even holds wages to be a fundamental exogeneous variable.

Consider the following static equilibrium model of a metropolitan area. Total output per time period is determined by an aggregate production function involving homogeneous capital and labor.

$$\text{IV:3:1)} \quad Q = F(K, L)$$

where: Q = total output of homogeneous goods

K = units of homogeneous capital

L = units of homogeneous labor

$\partial Q / \partial K$ and $\partial Q / \partial L$ are both positive

$\partial^2 Q / \partial K^2$ and $\partial^2 Q / \partial L^2$ are both negative

Demand for the output of the area depends on the price of output and on the total wage bill of the area. This second determinant of demand is due to the high transportation costs associated with many goods and is analogous to similar assumptions made in economic base models.

$$\text{IV:3:2)} \quad S = D(P, WL)$$

where: S = total sales of homogeneous output

¹ See, for example: Olvey, Lee Donne, "Regional Growth And Interregional Migration," Unpublished Harvard Ph.D. Dissertation, (April, 1970) and Muth, Richard, "Differential Growth Among Large U.S. Cities," in James P. Quirk and Arvid M. Zarley, eds., Papers in Quantitative Economics, (Lawrence, Kansas: The University Press of Kansas), 1968, pp.311-355.

where: P = price of output of the area

W = money wages in the area

$\partial S / \partial P$ is negative

$\partial S / \partial W$ is positive

The product market is closed by equating sales and output so that there is no net change in inventories.

IV:3:3) $S = Q$

In specifying the area demand function, the price of goods produced elsewhere is set equal to unity.

Factor markets in the metropolitan area, are assumed to be perfectly competitive and supply curves for capital and labor are assumed sufficiently price elastic to achieve a market clearing equilibrium with no unemployment or excess capacity.¹ There is no non-price rationing in factor markets. The supply of capital depends on relative rates of return in the area and the rest of the world, or nation, or region.

IV:3:4) $K = k(R/r)$

where: R = rate of return on capital in the area

r = rate of return on capital elsewhere

$dk/d(R/r)$ is positive

The supply of labor includes the migration function. Here migration is assumed to depend only on the ratio of real wages available in the area to the real wage rates prevailing

¹ These strong assumptions concerning the nature of the market clearing solution are not strictly necessary. The presence of excess capacity or unemployment could be incorporated in the rate of return and wage variables respectively.

elsewhere.

$$\text{IV:3:5)} \quad L = M(W/P, w) = M(W/Pw)$$

where: W = money wages in the area

P = price of output of the area

w = money wages available elsewhere

$dL/d(W/Pw)$ is positive

Note that since the price level elsewhere is unity, w is also the real wage elsewhere.¹ Finally the factor markets are closed, given the assumptions of no unemployment or excess capacity, by equating the rate of return on capital and the money wage to the value of the marginal physical product of capital and labor respectively.

$$\text{IV:3:6)} \quad W = P (\partial F / \partial L)$$

$$\text{IV:3:7)} \quad R = P (\partial F / \partial K)$$

The model now consists of seven equations in seven endogeneous variables, Q , S , K , L , W , R , and P , and three exogeneous variables including w , r , and prices elsewhere which were set equal to unity. Included in structural equation IV:3:5 is a standard migration function. The simultaneous equation problem involves determination of the consequences of attempting to estimate migration between the metropolitan area and other areas using a single equation

¹

It might be objected that real wages in the metropolitan area should be based on a weighted index of prices within and outside the area. The example here can be taken as the extreme case of weights equal to 1 and 0 respectively.

model.

Such a single equation approach would involve attempting to estimate equation IV:3:5 directly. If W , P , w , and prices elsewhere were all exogeneous, such an equation could be estimated and the partial relationships between changes in each of these variables and net migration flows determined.¹ However, real wages in the metropolitan area, W/P , appear in IV:3:6 as a function of $\partial F/\partial L$, which will in general have L , total labor force in the area, as one of its arguments. Indeed we have implicitly assumed this to be the case by assuming $\partial F/\partial L$ to be positive and $\partial^2 F/\partial L^2$ to be negative. Thus equations IV:3:5 and IV:3:6 combine to yield a classic case of simple simultaneous equation bias if estimated in a single equation model.

$$\text{IV:3:5)} \quad L = M(W/P, w)$$

$$\text{IV:3:6)} \quad W/P = \partial F/\partial L$$

Attempts to estimate a simple linear version of IV:3:5 and IV:3:6 illustrate the bias in a concrete context. Rewriting these two equations in terms of observed wages and migration gives:

$$\text{IV:3:8)} \quad L = a_0 + a_1(W/P) + a_2w + u$$

$$\text{IV:3:9)} \quad W/P = b_0 + b_1L + e$$

¹ This ignores aggregation problems discussed earlier

where: u and e = disturbances reflecting effects of other variables.

Single equation models attempt to estimate IV:3:8 directly and interpret the parameter a_1 as the partial derivative of migration with respect to changes in real wages, $\partial L / \partial (W/P)$. But these variables are connected by a second expression, IV:3:9. If, as a priori conditions suggest, b_1 is negative, then the covariance of u and (W/P) will be negative. Attempts to estimate IV:3:8 by ordinary least squares will result in a downward bias in estimates of a_1 due to the negative covariance between W/P and the residual term u .

Difficulties inherent in single equation estimates drawn from the structural model have led researchers to estimate reduced form relationships between wages and population change. This reduced form approach has been the subject of extensive empirical work reviewed in Chapter II:3. The seven equation system, IV:3:1 through IV:3:7, can be evaluated using comparative statics for the total derivative of population with respect to changes in exogeneous external wages.

$$\text{IV:3:10) } \frac{dL}{dW} = \partial M / \partial W - \frac{(\partial M / \partial W)}{(\partial F / \partial L - \partial D / \partial L)(\partial M / \partial W) / (\partial D / \partial W)}$$

If worker wages are larger than expenditures on local goods, $(F/L - D/L)$ is positive. Since (M/W) and (D/W) are both positive, the two terms on the right side of IV:3:10 have opposite signs. Thus the sign of dL/dw is ambiguous. This result agrees with empirical evidence.

The arguments presented above leave the impression that the simultaneous equation problem only concerns the coefficient of W/P in the migration equation. But there are further problems involved in estimating the migration equation presented in this simultaneous equation model. Careful examination shows that the migration equation is not identified. The only excluded exogeneous variable is r and there are at least two included endogeneous variables. This is not intended to suggest that it is not possible to formulate simultaneous equation models in which there is sufficient a priori information to identify the migration equation, but the data and theory requirements of such models might be extensive.

IV:4) Interaction Between Aggregation And Simultaneous Equation Problems

The greatest difficulty in implementing simultaneous equation models results from the interaction of aggregation and simultaneous equation problems. The simple model presented above involved homogeneous labor and capital. Of course labor is heterogeneous and, most important, there is a systematic relationship between relative mobility of different groups and the wages of these groups. This systematic relationship tends to obscure the size and

direction of the change in money wages accompanying a change in labor force due to net migration flows.

The aggregation problem arises in equation IV:3:6 of the model presented in the previous section because actual wage data is only available in dollars per manhour by industry or, less readily, by occupation for metropolitan areas. There is little if any possibility of constructing a wage index based on the level of compensation for given education, or skill.¹ But migration rates tend to increase very sharply with the number of years of education. It is well known that areas of chronic heavy net out migration accumulate unskilled and uneducated workers in exceptional concentrations. The strong relationship between education and relative mobility is presented in Table IV:2:2 above.

Thus areas experiencing large inflows of migrants will tend to find the average educational level of their work force increasing. This will tend, *ceteris paribus*, to cause the wage index, based on compensation per manhour, to rise for such areas. This effect is directly opposed to direction of wage determination in the productivity equation which suggests increases in the labor force are associated, *ceteris paribus*, with a decline in wages.

These effects may be analyzed in terms of a simple model.

¹The greatest empirical difficulty involved in constructing such an index is that the level of educational achievement represented by given years spent in school varies by region.

In the model presented in the previous section, real wages per manhour of homogeneous labor were determined in a simple productivity equation.

$$\text{IV:4:1)} \quad W = \partial Q / \partial L$$

where: W = real wages per manhour

Q = output

L = manhours of homogeneous labor

The real wage index used here is based on the format in which the data are normally computed and used in migration models. The total wage bill is deflated by a price index and divided by total manhours. There is an unambiguous relationship between migration flows that change the size of the labor force by adding more units of homogeneous labor and resulting wage changes.

$$\text{IV:4:2)} \quad \partial W / \partial L = \partial^2 Q / \partial L^2 < 0$$

This formulation implicitly assumes that migrants are not distinguishable from the population in general.

If workers are differentiated by skill or education level, the production function must be reformulated to indicate the effect of these skills on total output from given capital and manhours. One way of formalizing the effect of skill levels on output is to measure labor input in equivalent efficiency units of labor.

$$\text{IV:4:3)} \quad Q = F(K, H)$$

where: H = total labor input in efficiency units

Similarly wages per efficiency unit of labor may be defined.

$$\text{IV:4:4)} \quad E = \partial F / \partial H$$

where: E = real wages per efficiency unit of labor

The real wage per manhour in the area is equal to the real wage per efficiency unit of labor multiplied by average level of efficiency units per worker.

$$\text{IV:4:5)} \quad W = E (H/L)$$

Now if the area receives immigrants from another region the effect on measured real wages per manhour may be found by evaluating the total differential of IV:4:5.

$$\text{IV:4:6)} \quad dW/dL = (\partial W / \partial E) dE/dL + (\partial W / \partial H) dH/dL + (\partial W / \partial L)$$

This may be rewritten after appropriate substitution as:

$$\text{IV:4:7)} \quad dW/dL = (H/L) dE/dL + (E/L) dH/dL - EH/L^2$$

If the level of efficiency units per immigrant is known, the impact of migration on measured real wages may be further evaluated.

$$\text{IV:4:8)} \quad dE/dL = (dE/dH)(dH/dL) = (\partial^2 Q / \partial H^2) h$$

$$\text{IV:4:9)} \quad dH/dL = h$$

where: h = efficiency units per migrant.

Substituting the results of IV:4:8 and IV:4:9 into IV:4:7 gives a much more satisfying expression for the change in the real wage per manhour.

$$\text{IV:4:10)} \quad dW/dL = (H/L)(\partial^2 Q / \partial H^2)h + (E/L)h - (E/L)(H/L)$$

Noting that (H/L) is the efficiency units per worker in the area, we can rewrite IV:4:10 so that the sign of dW/dL can be expressed in terms of the difference in skill level between migrants and resident workers.

$$\text{IV:4:11)} \quad dW/dL = (H/L)h(\partial^2 Q / \partial H^2) + (E/L) (h - H/L)$$

$$\text{where: } (H/L)h(\partial^2 Q / \partial H^2) < 0$$

Thus the sign of dW/dL depends on the relationship between h and H/L .

There is strong evidence that h is larger than H/L . Migrants are far more educated than the general population. Thus even if the capital stock and technology are unchanged the total effect of immigration on the real wage per manhour is ambiguous. Indeed, to the extent that migrants are far more skilled than the general workforce, real wages per manhour may rise in areas receiving large migrant inflows! Conversely real wages per manhour may fall in areas losing population through migration.

CHAPTER V

EMPIRICAL TESTS OF THE MODEL

This chapter contains an empirical evaluation of the job-search model of migration developed in Chapter III mindful always of the difficulties catalogued in Chapter IV. Data limitations are a constant hindrance to empirical work on migration and the model specifications presented here represent an attempt to adapt theory to available data. The next two sections of this chapter develop a particular specification of an aggregate migration function and possible strategies for promoting consistent aggregation. Finally estimates of migration functions are made using data on migration from the United States and United Kingdom.

V:1) Specification Of An Aggregate Migration Function

In chapter III the necessity of making assumptions concerning the actual distributions of wages in different areas was pointed out. Inevitably there is an element of arbitrary specification in choice of wage distributions since, due largely to lack of data, there is little literature on this topic. Given the limited availability of data on migration and wages, it is not clear that an elegant formulation of wage distributions would make it possible to estimate more precise functions.

Consider the case in which offered wages are uniformly distributed at a particular location.

$$V:1:1) \quad f_{w_{oi}}(w) = \begin{cases} 1/I & \text{for } 0 \leq w \leq I \\ 0 & \text{elsewhere} \end{cases}$$

where: $f_{w_{oi}}(w)$ = probability density function of offered wages at i .

Substituting into III:3:4 gives the expected value of the maximum wage found in n_i searches.

$$\begin{aligned} V:1:2) \quad w_{oi}^M(n_j) &= \int_0^I n_j w (F_{w_{oi}}(w))^{n_j-1} f_{w_{oi}}(w) dw \\ &= \int_0^I n_j w \left(\int_0^w (1/I) dw \right)^{n_j-1} (1/I) dw = (n_j/n_j+1)I \end{aligned}$$

Thus the expected value of the maximum wage found is an increasing function of n_j which increases at a decreasing rate, as the first and second derivatives illustrate.

$$V:1:3) \quad dw_{oi}^M(n_j)/dn_j = I/(n_j+1)^2 > 0$$

$$V:1:4) \quad d^2w_{oi}^M(n_j)/dn_j^2 = -2I/(n_j+1)^3 < 0$$

The conditions in V:1:3 and V:1:4 are of course necessary to insure that only a limited number of searches will be made and so that $w_{oi}^M(n_j)$ for the number of searches anticipated will be less than I , the maximum offered wage.

Substituting $w_{oi}^M(n_j)$ and $dw_{oi}^M(n_j)/dn_j$ from the above results into the necessary conditions for search to maximize income and derived in III:3:7, gives a relationship which can be solved for $w_{oi}^M(n_j)$.

$$V:1:5) \quad w_{oi}^M(n_j) = (a_i - a_j) + w_i + (T - n_j)I/(m_j+1)^2 - \partial c_{ij}^*/\partial n_j$$

In V:1:5, $w_{oi}^M(n_j)$ is the expected value of the maximum offered wage found in the number of searches, n_j , which is consistent with a maximum of income. This means that it is possible to solve for the optimal number of searches, n_j , by substituting the solution for $w_{oi}^M(n_j)$ from V:1:2 in equation V:1:5.

$$V:1:6) (n_j/n_j+1)I = (a_i - a_j) + w_i + (T - n_j)I/(n_j+1)^2 - \partial C_{ij}^*/\partial n_j$$

Equation V:1:6 can be rewritten as a quadratic form in n_j .

$$V:1:7) 0 = n_j^2 + 2n_j + C$$

$$\text{where: } C = (a_i + w_i + IT - a_j - \partial C_{ij}^*/\partial n_j) / (a_i + w_i - I - a_j - \partial C_{ij}^*/\partial n_j)$$

Substituting V:1:7 into the quadratic formula, it is apparent that n_j has at most one positive root whose magnitude varies directly with the absolute value of C .

$$V:1:8) n_j = (-2 \pm \sqrt{4 - 4C})/2$$

From V:1:8 it follows that if search is to be undertaken at all, ($n_j > 0$), C must be less than zero. Since the numerator of C is larger than the denominator, if C is to be negative the denominator must be negative or: $w_i + a_i < a_j + I + \partial C_{ij}^*/\partial n_j$. Thus if there is to be any search at j the worker's present wages and attractiveness at i , ($w_i + a_i$), must be less than his view of the potential position available at j , ($a_j + I$), plus search costs for an initial search.

Thus search effort at j increases directly with the absolute value of C . The effect of the arguments of C on search effort is found by differentiating C .

$$V:1:9) \quad \partial C / \partial a_i = -I(1+T)/V^2 < 0$$

$$V:1:10) \quad \partial C / \partial a_j = I(1+T)/V^2 > 0$$

$$V:1:11) \quad \partial C / \partial (\partial C_{ij}^* / \partial n_j) = I(1+T)/V^2 > 0$$

$$V:1:12) \quad \partial C / \partial w_i = -I(1+T)/V^2 < 0$$

$$V:1:13) \quad \partial C / \partial I = (T+1)(a_i + w_i - a_j - \partial C_{ij}^* / \partial n_j) / V^2 \geq 0$$

$$V:1:14) \quad \partial C / \partial T = I > 0$$

where: $V = (a_i - a_j - \partial C_{ij}^* / \partial n_j + w_i - I) = \text{denominator of } C$

The one surprising result in the results above is the ambiguous relationship between search effort and the maximum offered wage, I . However, careful examination of equation V:1:13 shows that, only if search costs are very high and if the attractiveness of area j , a_j , greatly exceeds that at i , is I inversely related to number of searches at j . Another most important, if not surprising result, is the inverse relationship between current wages, w_i , and search effort. Workers in high wage firms are less likely to engage in extensive search. This is precisely why firms offer and maintain wage schedules above those of competitors.

An additional important result follows from equation V:1:5. $w_{oi}^M(n_j)$ is the expected value of the maximum offer found in the number of searches, n_j , which is consistent with a maximum of expected income. But this is the offer acceptance wage of a worker at i who is presently receiving

a wage of w_1 . This analysis is sufficient for one worker but the acceptance wage applicable to an aggregate migration function is a random variable based on a transformation of the distribution of wages at i . The distribution of offered wages at i has already been assumed to be $f_{w_{0i}}(w)$ in equation V:1:1. This is the distribution of wages associated with unfilled vacancies at i . There is no reason to assume, based on either a priori or empirical evidence available, that the distribution of wages attached to unfilled vacancies differs substantially from that of actual wages prevailing in the area. In light of this, the actual wage distribution at i will be assumed to be the same as the offered wage distribution at i .

$$V:1:15) \quad F_{w_1}(w) = \int_0^w f_{w_1}(w) dw = \int_0^w (1/I) dw$$

where: $F_{w_1}(w)$ = cumulative density function of w_1

$f_{w_1}(w)$ = probability density function of w_1 .

Following equation V:1:6, it is possible to derive the cumulative frequency distribution of w_{aij} in terms of the probability density function of w_1 .

$$V:1:16) \quad F_{w_{aij}}(w) = \int_0^{a_1 - a_j - C_{ij}^* / n_j + (T - n_j)I / (n_j + 1)^2 - w_{aij}} f_{w_1}(w) dw$$

$$= (a_1 - a_j - C_{ij}^* / n_j + (T - n_j)I / (n_j + 1)^2 - w_{aij}) / I$$

From V:1:6: $w_1 = a_1 - a_j - C_{ij}^* / n_j + (T - n_j)I / (n_j + 1)^2 - w_{aij}$

The marginal density function of acceptance wages at i for offers from j is found in the usual way, by differentiating the cumulative density function in V:1:16 with respect to w_{aij} .

$$\text{V:1:17) } f_{w_{aij}}(w) = dF_{w_{aij}}(w)/dw_{aij} = \begin{cases} 1/I & 0 \leq w \leq I \\ 0 & \text{elsewhere} \end{cases}$$

In this case, offer acceptance wages are uniformly distributed just as offered wages were. Obviously the relative simplicity of the model developed thus far is due in large part to the simplicity of the assumptions concerning fundamental wage distributions.¹

The next step in the model is solution for the aggregate offer acceptance probability. This depends both on the acceptance wage and the distribution of offered wages at the destination. By symmetry with the offered wage distribution assumed for area i .

$$\text{V:1:18) } F_{w_{oj}}(w) = \int_0^J f_{w_{oj}}(w) dw = \int_0^J (1/J) dw$$

where: $F_{w_{oj}}(w)$ = the cumulative density function of offered wages at j .

$f_{w_{oj}}(w)$ = the probability density function of offered wages at j .

In equation III:5:6 the offer acceptance probability for offers from j by workers from i was shown to depend on the

¹The range of wages beginning at 0 may seem low, but it reflects, in part, current earnings of members of the labor force who are currently unemployed.

joint probability density function of acceptance wages at i and of offered wages at j . Since these two distributions are independent, the joint density function may be written as the product of the two marginal density functions.

$$V:1:17) \quad f_{w_{aij}, w_{oj}}(w_a, w_o) = f_{w_{aij}}(w_a) f_{w_{oj}}(w_o) = \begin{cases} 1/IJ & 0 \leq w_a \leq I \\ & 0 \leq w_o \leq J \\ 0 & \text{elsewhere} \end{cases}$$

Since offer acceptance follows directly upon finding an offer that equals or exceeds the relevant acceptance wage, the problem is to define the probability law of a new random variable such that the difference of offered and acceptance wages is positive. The new random variable is equal to the difference of offered and acceptance wages.

$$V:1:18) \quad p_a = (w_o - w_a)$$

The aggregate offer acceptance probability, P_{aij} , is equal to the cumulative density function over the range $p_a = 0$ to $p_a = I$. Solving for the cumulative density function in terms of the sample space of w_o and w_a gives an expression for P_{aij} in terms of I and J .

$$V:1:19) \quad P_{aij} = (J/I) - \frac{1}{2}(I/J)$$

Differentiating P_{aij} with respect to both I and J gives results which indicate that P_{aij} increases at a decreasing rate with J and decreases at a decreasing rate with I .

$$V:1:20) \quad \partial P_{aij} / \partial J = (1/I) + \frac{1}{2}(I/J^2), \quad \partial^2 P_{aij} / \partial J^2 = -(2I/J^3)$$

$$V:1:21) \quad \partial P_{aij} / \partial I = (-J/I^2) - (1/2J), \quad \partial^2 P_{aij} / \partial I^2 = 2J/I^3$$

The offer acceptance probability, P_{aij} , may be expressed in terms of the expected value of wages at the origin and destination.

$$V:1:22) \quad E(w_{aij}) = \int_0^I f_{w_{aij}}(w) dw = I/2$$

$$V:1:23) \quad E(w_{oj}) = \int_0^J f_{w_{oj}}(w) dw = J/2$$

Substituting V:1:22 and V:1:23 into equation V:1:19 gives an expression for P_{aij} in terms of expected values of wages.

$$V:1:24) \quad P_{aij} = (E(w_{oj})/E(w_{aij})) - \frac{1}{2} (E(w_{aij})/E(w_{oj}))$$

The similarity between V:1:19 and V:1:24 is obvious and extends to the respective derivatives which follow the pattern of equations V:1:20 and V:1:21. Aggregate offer acceptance probability increases at a decreasing rate with $E(w_{oi})$ and decreases at a decreasing rate with $E(w_{aij})$.

The remaining complex element in the formulation of an aggregate migration function such as III:5:7 is the distribution of search effort. In equation III:5:7 search effort, S_{ij} , has the dimension of number of searches per year per potential migrant at i in area j . A neutral assumption concerning the distribution of search effort per potential migrant would have to have search distributed evenly among vacancies at all alternative destinations.

$$V:1:25) \quad S_{ij} = s_i(V_j/V_T)$$

where: V_j = job vacancies in area j

V_T = total vacancies at all locations

s_i = constant of proportionality reflecting the number of searches per worker per time period.

Equation V:1:25 obviously involves strong assumptions concerning total search effort and its distributions.

The analysis developed in this section, and particularly equations V:1:9 through V:1:14, indicates the determinants of s_i for a worker at i with wage w_i . In general total search effort at i was found to vary directly with attractiveness of the destination, a_j , expected duration of employment in the new job, T , difference between present wages and maximum wages at i , $(I-w_i)$; and inversely with attractiveness of the origin, a_i . These effects are fairly straightforward in the aggregate expression developed for search effort, but the difference between present and maximum wages, $(I-w_i)$, varies for each worker. For all workers at i , the expected value of the difference $(I-w_i)$ is equal to $I/2$. In general the expected value of the difference between the maximum wage and any observed wage will increase with the variance of the wage distribution at i . Thus on the basis of the a priori information in equations V:1:9 through V:1:14, the following

properties may be attributed to the functional form of s_i .

$$V:1:26) \quad s_i = S_i (T, (a_j - a_i), \text{var}(w_i))$$

where: $\text{var}(w_i)$ = variance of wages at i .

$$\partial S_i / \partial T > 0 \text{ from } V:1:14$$

$$\partial S_i / \partial (a_j - a_i) > 0 \text{ from } V:1:9 \text{ and } V:1:10^1$$

$$\partial S_i / \partial \text{var}(w_i) > 0 \text{ from } V:1:12 \text{ and } V:1:14$$

Thus aggregate search effort at i depends on the time horizon of workers, the relative attractiveness of i , and the variance of wages in area i .

The distribution of search effort among alternative destinations is more complex than the proportional distribution implied by $V:1:25$ suggests. Equation $III:5:9$ demonstrates that the sum of attractiveness plus marginal search cost be equal for all areas searched. Equation $V:1:25$ may be rewritten to reflect the influence of attractiveness and search costs on the distribution of search effort.

$$V:1:27) \quad S_{ij} = s_i (V_j / V_T) d_{ij}$$

where: d_{ij} = differential search effort

The shape of the search cost function is vital to the determination of the distribution of search effort, d_{ij} . If search costs at one location were lower than at alternative locations and there were no significant differences in

¹ There is no loss in generality when the s_i function is written in terms of the difference in attractiveness, $(a_j - a_i)$, because in $V:1:9$ and $V:1:10$ $\partial C / \partial a_j$ and $\partial C / \partial a_i$ have equal magnitude and opposite signs.

attractiveness, all search effort would be concentrated in one area.

The search cost function is generally thought to vary with the distance between origin and destination as well as the migrant stock from the destination presently in residence at the origin. The reason for the importance of distance is that personal trips and interviews are often part of the search process and are sometimes paid for by workers. Migrant stock from the destination in residence at the origin is thought to reduce search costs for individuals who rely on friends and relatives for labor market information.¹

In Chapter III:4 an additional important argument of the search cost function was developed based on recruiting efforts of firms at distant locations. Firms were shown to maximize profits by minimizing recruiting costs. Those firms located in the highest wage areas were shown in equation III:4:6 to recruit more intensively at alternative destinations than firms in lower wage areas.

Differential search effort defined in equation V:1:27 can be expressed as a function of attractiveness and search costs.

$$V:1:28) \quad d_{ij} = D_{ij} ((a_j - a_i), (C_i - C_{ij}))$$

where: $(C_i - C_{ij})$ = the difference in search costs at the origin and destination

¹For an elaboration of the migrant stock hypothesis, see: Fabricant, Ruth, "An Expectational Model of Migration," Journal of Regional Science, Vol. 10, (April, 1970), pp. 13-24.

Equation III:4:6 suggests that $\partial D_{ij}/\partial a_i = -\partial D_{ij}/\partial a_j$ and the arguments of D_{ij} are written accordingly as a difference in attractiveness. Substituting the arguments of C_{ij} developed above into V:1:28 gives a new expression for d_{ij} .

$$V:1:29) \quad d_{ij} = D_{ij}((a_j - a_i), (C_i - C_{ij}(r_{ij}, \bar{M}_{ji}, E(w_{oj}))))$$

where: r_{ij} = distance between i and j or sometimes transportation cost from i to j is used.

\bar{M}_{ji} = migrant stock from j in residence at i
(the summation of past migration flows from j to i)¹

$E(w_{oj})$ = expected value of offered wages at j .

This discussion of determinants of the distribution of search effort among destinations is necessarily less concrete than other elements of the migration function. The ambiguity in D_{ij} is due largely to the lack of information, other than that provided by survey literature, on the search cost function. There is enough a priori information from the model in Chapter III to specify the partial effects of the arguments of D_{ij} .

$$V:1:30) \quad \partial D_{ij} / \partial (a_j - a_i) > 0$$

$$V:1:31) \quad \partial D_{ij} / \partial C_i > 0$$

$$V:1:32) \quad \partial D_{ij} / \partial r_{ij} < 0$$

$$V:1:33) \quad \partial D_{ij} / \partial \bar{M}_{ji} > 0$$

¹ The general assumption in the literature is that migrants from j to i lower search costs at j for workers in i . There is a possibility that the migrant stock from i at j may lower the cost of searching at j for workers from i . Trivial modification of the D_{ij} function would accomodate this assumption.

$$V:1:34) \quad \partial D_{ij} / \partial E(w_{oj}) > 0$$

Thus search effort is relatively concentrated in destinations which are near the origin, have high wages, and have many former residents at the origin.

By making concrete assumptions concerning the character of wage distributions at the origin and destination, the elements of the migration function derived in KKK:V:7 have been supplemented by a great deal of a priori information. Using results from equations V:1:24, and V:1:26 through V:1:29, it is possible to rewrite III:V:7 in terms of the results obtained in this chapter.

$$V:1:35) \quad M_{ij} = P_{aij} P_i s_i (V_j/V_T) d_{ij} \\ = \left[\frac{E(w_{oj})}{E(w_{aij})} \cdot \frac{E(w_{aij})}{E(w_{oj})} \right] P_i s_i [T, (a_j - a_i), \text{var}(w_i)] (V_j/V_T) \\ D_{ij} [(a_j - a_i), (C_i - C_{ij})(r_{ij}, \bar{M}_{ji}, E(w_j))]$$

The derivatives of M_{ij} with respect to each of the functions in V:1:35 have already been determined and will not be repeated here. However these derivatives represent a body of a priori information which can be applied to a simulation or estimation of migration between metropolitan areas. Obviously V:1:35 is partly the product of the specific wage distributions chosen. But the derivation of V:1:35 is based on direct implementation of the results of Chapter III. Similar procedures could be followed in developing migration equations from other wage distributions.

V:2) Aggregate Migration With Heterogeneous Labor

Thus far the difficulties introduced in Chapter IV by migration of heterogeneous labor have been ignored. There are difficulties in aggregating over parameters and over variables where workers are not homogeneous. A simple model developed here illustrates a range of feasible approaches to the aggregation problem. Unfortunately data limitations force investigators to work both with aggregate migrant flows and equally aggregate variables describing the condition of urban labor markets.

The aggregation problem may be considered first in terms of the offer acceptance probability term in the migration function. Consider first aggregation over micro parameters. Following Chapter IV, let there be demographic groups $k = 1, \dots, K$ distributed such that there are N_k^i members of group k at i and N_k^j members of group k at j . Following V:1:24, offer acceptance probability may be written as a linear function of relative wages with a parameter specific to demographic group k .

$$V:2:1) \quad p_{aij}^k = b_k (E(w_{oj}) / E(w_{aij}))$$

where: p_{aij}^k = offer acceptance probability for an individual member of group k .

The aggregate offer acceptance probability can be written in terms of the micro parameters, b_k .

$$V:2:2) \sum_{k=1}^K (N_k^i/N^i) P_{aij}^k = \sum_{k=1}^K (N_k^i/N^i) b_k (E(w_{oj})/E(w_{aij}))$$

where: $N^i = \sum_{k=1}^K N_k^i$

In estimating an aggregate migration function, it is necessary to specify V:2:1 in terms of a macro parameter B^i .

$$V:2:3) B^i = \sum_{k=1}^K (N_k^i/N^i) b_k$$

Substituting V:2:3 into V:2:2 gives an expression for aggregate offer acceptance probability in terms of the macro parameter B^i .

$$V:2:4) \sum_{k=1}^K (N_k^i/N^i) P_{aij}^k = \left[\frac{\sum_{k=1}^K (N_k^i/N^i) b_k (E(w_{oj})/E(w_{aij}))}{\sum_{k=1}^K (N_k^i/N^i) b_k} \right] B^i$$

$$= (E(w_{oj})/E(w_{aij})) B^i$$

While equation V:2:4 is susceptible to consistent aggregation since the expression in brackets reduces to a ratio of expected wages, the aggregate parameter B^i is characteristic of area i only. If migration from more than one origin is to be considered, then B^i must be considered a variable which can be handled by strategic introduction of dummy variables. It is important to note that the B^i 's generated for the origins only can be assumed to fall within the range of values of the b_k 's such that: $\min_k b_k \leq B^i \leq \max_k b_k$.

It is possible to use some of the evidence developed earlier to estimate macro parameters that better illuminate the micro parameters, b_k . In tables IV:2:1 and IV:2:2 it was argued that differences in age and education of workers account for the largest proportion of the differences among micro parameters. The relative differences in propensity to move can be read from these tables and used to form "aggregating factors" that are proportional to the relative propensity to move.

$$V:2:5) \quad b_k = b^* A_k$$

where: A_k = relative propensity of group k to migrate

$$\sum_{k=1}^K A_k = 1$$

Once a set of A_k 's, $k = 1, \dots, K$, has been obtained, it is possible to express the macro parameter B^i in terms of the standardized micro parameter, b^* .

$$V:2:6) \quad B^i = b^* \sum_{k=1}^K (N_k^i / N^i) A_k = b^* \sum_{k=1}^K A_k^i$$

where: A_k^i = aggregating factor weighted by size of population subgroups at i .

After a set of generalized A_k 's have been calculated, a set of specific aggregating factors A_k^i can be calculated for each origin.

The results of V:2:6 may be substituted directly into V:2:4 to give an expression for aggregate offer acceptance probability in terms of a single parameter, b^* .

$$V:2:7) \sum_{k=1}^K (N_k^1/N^1) p_{aij}^k = b^* A_k^1 (E(w_{oj})/E(w_{aij}))$$

In effect the aggregation problem has been incorporated in the variable A_k^1 . The parameter b^* is a constant that may be estimated consistently in an aggregate crossection study of migrants from many origins. A set of these aggregating factors is used in the estimation of aggregate migration equations in Table V:4:2.

The aggregation problem may also extend to the variables of a function, specifically the wage variables. Workers are only qualified for a small fraction of all vacancies. If each of the K demographic groups has a separate set of jobs, and hence wages, then V:2:1 may be rewritten in terms of wages associated with a particular group.

$$V:2:8) p_{aij}^k = b_k (E(w_{oj}^k)/E(w_{aij}^k)) = b_k (w_{oj}^k/w_{aij}^k)$$

The aggregate offer acceptance probability can be written in terms of the micro parameters, b_k , and specific wages, $E(w_{oj}^k)$ and $E(w_{aij}^k)$.

$$V:2:9) \sum_{k=1}^K (N_k^1/N^1) p_{aij}^k = \sum_{k=1}^K (N_k^1/N^1) b_k (w_{oj}^k/w_{aij}^k)$$

Wage indexes normally observed are based on a weighted average of wages received by each of the K groups.

$$V:2:10) E(w_{oj}) = \sum_{k=1}^K (N_k^j/N^j) w_{oj}^k$$

$$V:2:11) E(w_{aij}) = \sum_{k=1}^K (N_k^i/N^i) w_{aij}^k$$

Substituting V:2:10 and V:2:11 into V:2:9 gives an expression for aggregate offer acceptance probability in terms of the macro variables $E(w_{oj})$ and $E(w_{aij})$.

$$V:2:12) \sum_{k=1}^K (N_k^i/N^i) p_{aij}^k = \left[\frac{\sum_{k=1}^K (N_k^i/N^i) b_k (w_{oj}^k/w_{aij}^k)}{\sum_{k=1}^K (N_k^j/N^j) w_{oj}^k / \sum_{k=1}^K (N_k^i/N^i) w_{aij}^k} \right] \left[\frac{E(w_{oj})}{E(w_{aij})} \right]$$

The micro parameter b_k may be eliminated from V:2:12 in similar fashion to the arguments made above which resulted in equation V:2:7. But an expression which involves the summation of relative wages will remain in the numerator and the denominator of V:2:12 will be unchanged. Unless $N_k^j/N^j = N_k^i/N^i$ for all $k = 1, \dots, K$, the large expression in brackets in V:2:12 will be a variable, depending on the distribution of population among the K subgroups at i and j . This is the same result developed in abstract form in Chapter IV and embodied in equations IV:1:13 and IV:1:14. For each origin-destination pair, the parameter associated with the relative wage variable will be different.¹ The obvious solution to the consistent aggregation problem described here is to develop destination wage indexes based on weights, N_k^i/N^i , derived from the origin. This would require micro wage data which are not available.

¹In this section offer acceptance probability is expressed as a simple ratio of wage rates in order to simplify the algebra.

V:3) Data On Migrant Flows Between Metropolitan Areas

There are three basic data sources for migrants between metropolitan areas in the United States: the Social Security Administration 1% sample; the 1960 Census 25% household sample; and net migration calculated as a residual in adjusting population totals to the 1950-60 intercensal period. Each source has advantages for or in particular uses, but the task involved here is the estimation of an aggregate migration function.

The 1% Social Security sample consists of 830,000 card images for the four annual periods: 1959-60; 1960-61; 1961-62; and 1962-63. About 680,000 represent the history of a cohort that appears in the sample in all four periods. This means that time series experience on 170,000 cases is available. Thus the number of migrants in the sample is small, and the number moving between a particular origin-destination pair is smaller still. However a major difficulty accompanies any attempt to use social security data as a sample of the population in general. Obviously the social security file omits occupations not covered under O.A.S.D.I. In addition the Social Security Administration did not create a random sample of its files. The 1% sample consists of disproportionate numbers of very young workers just entering the labor market

and older workers about to leave it. The Social Security Administration sample does not provide an ideal basis for estimation of aggregate migration between metropolitan areas.

The source of data on migrants between SMSAs in the U.S. is the same as that used by Ira Lowry and other investigators.¹ A question designed to monitor migration was added to the 1960 Census of Population on the Household Questionnaire. Self enumeration was performed by the household. This innovative enumeration technique and the change in questions on migration as compared to 1950 makes the 1960 data series used in this thesis a unique source.

The specific question from which migrant flows between SMSAs was P 13:

P13 Did he live in this house on April 1, 1955?
(Answer 1, 2, or 3)

1. Born on April 1955 or later
2. Yes, this house
3. No, different house

Where did he live on April 1, 1955?

- a. City or town
- b. If city or town - Did he live inside city limits?
- c. County and State

Note that this question is not designed to determine the

¹ Following Lowry, a random sample of 100 migrant flows was chosen from a possible 19 by 19 table of migrant flows between the largest SMSAs in the U.S. that appears in: Department of Commerce, Bureau of the Census, Census of Population 1960: Mobility for Metropolitan Areas, Report PC2-(2C), Washington, D.C.: U.S. Government Printing Office, (1963).

totality of moves made by the individual. Thus the data do not give gross flows in the sense of monitoring individual moves, but only two snapshot views of the individual's location at two points in time. Since the majority of inter-city migrants in any year are transient individuals who move many times in their lifetime, the five year time period has the effect of raising the proportion of relatively stable individuals to transient individuals.¹ The obvious difficulty with this long time period is that labor market conditions in an area could vary substantially over such a time period.

Net migration totals for an intercensal period have been used mainly in descriptive studies of population flows. This series does not yield specific flows between areas. It gives only net population flows between an origin and the rest of the country.

Migration between areas in the United Kingdom is also included in this study.² The data are based on the 1961 Census of U. K. population in which a specific question was asked concerning area of former usual residence by area of

¹ For an example showing the importance of transient workers in accounting for aggregate migration, see: Goldstein, Sidney, Patterns of Mobility 1910-1950: The Norristown Study, (Philadelphia, Pa.: University of Pennsylvania Press), 1958.

² 1961 Census of the Population, Table 5A, and 1966 Census of the Population, Table 5A. Data consists of a 6 by 6 table of migrant flows among 6 metropolitan areas in the U.K. One table for 1960-61 and one for 1965-66. See: Masser, I., op.cit., pg. 38.

present usual residence. A similar question was asked on the 1966 sample Census of the Population. In both cases the sample size was 10% of the population. The U.K. data has the advantage of permitting a crossection of time series. But data on labor market conditions by area are difficult to find for the United Kingdom.

V:4) Estimation of an Aggregate Migration Equation

The task in this section involves the estimation of equation V:1:35. This requires some assumption regarding the exact functional form of some expressions as well as compromise between available data and the form of the variables contained in the specification based on theory only. In the initial formulation of an exact specification of the model for estimation, aggregation problems will be neglected.

There is no difficulty in observing aggregate wages at various locations but a key element of V:1:35, vacancies in different labor market areas, cannot be observed. Probably the best proxy for the average number of vacancies available at a particular location over the five year period spanned by the data on migrants is total employment in the area. In any but the fastest growing labor market areas, the greatest source of vacancies is voluntary separations due either to

retirements or normal turnover. Both of these determinants or generators of vacancies should vary directly with total employment in the local area.

Some of the arguments of V:1:35 cannot be observed but would not appear to differ systematically among areas. Thus T , the time horizon of the worker, and C_1 , search costs at the origin, and the variance of wages at the origin have not been the object of investigation in the social science literature. However, there is no reason to assume that these variables are correlated with other arguments of the migration function. This reduces the possibility of bias due to excluded variables but leaves the residual term in any estimation larger than it might have been with a more complete specification.

The qualifications described above leave V:1:35 greatly simplified, containing only variables that can be observed directly or indirectly.

$$V:4:1) \quad M_{ij} = \left[\frac{E(w_{oj})}{E(w_{a1j})} - \frac{E(w_{a1j})}{E(w_{oj})} \right] E_i S_i [(a_j - a_i)] (E_j / E_T) \\ D_{ij} [(a_j - a_i), -C_{ij}(r_{ij}, \bar{M}_{ji}, E(w_{oj}))]$$

where: E_i = employment in area i

E_j = employment in area j

E_T = total employment,

The term $(a_j - a_i)$ appears in both the S_i and D_{ij} functions. However in both cases the functions increase directly with $(a_j - a_i)$, since $\partial S_i / \partial (a_j - a_i)$ and $\partial D_{ij} / \partial (a_j - a_i)$ are both positive.

As is the case with other elements of the migration function, differences in attractiveness cannot be observed directly in the units or dimensions cited in the migration equation. Instead of observing attractiveness in equivalent dollar units, it is only possible to monitor the physical attributes of the area. Attractiveness includes desirable elements of an area (or undesirable attributes) for which there is no market, goods for which excludability is not feasible and/or public goods. This is precisely why it is not possible to observe prices for attractiveness at various locations. Indeed were such prices available they would be used to convert money wages into real wages.

The characteristics of attractiveness usually cited in the migration literature deal with climate, specifically comparing average temperature at the origin and destination. An additional attribute of metropolitan areas not subject to excludability is environmental quality, particularly air quality. Three physical measures reflecting physical aspects of climate, and

environmental quality are used in this study. Climate is represented by the mean wind-chill factor during the three winter months and the mean temperature-humidity index during the three summer months. Both these indexes are designed to reflect the compound effect of several climatic factors on human comfort and/or survival. Air quality is embodied in an index of the mean number of clear days per year.¹ Many other attributes of particular metropolitan areas could be cited as elements of attractiveness. The sample of areas actually selected for study was designed to omit areas with unique characteristics that might affect their desirability as places of residence.

Other arguments of the D_{ij} function include determinants of search cost: distance between areas; migrant stock from the destination in residence at the origin; and the expected value of destination wages. Of these variables distance is observable both in physical terms and as transportation cost while mean destination wages are available for SMSA's.

Unfortunately the only data on migrant stock is derived from census questions on the state of birth the population by state of current residence. This is, at best, a crude indication of

¹Reliable data on air pollution for metropolitan areas are not available for the 1955 - 1960 period during which the observations of migrants in the 1960 Census were made.

number of individuals in residence at the origin who have a detailed knowledge of destination labor markets. Much of the migrant stock recorded at a particular location may have little current knowledge of conditions in the city in which they were born. Thus the migrant stock data available for states has very little relevance for the metropolitan area migration function in V:4:1.

The elimination of the migrant stock variable from the estimations performed in this chapter undoubtedly raises the standard error of the estimate. However there is no reason to assume that the omitted migrant stock variable is correlated with any of the regressors.¹ In this sense the omission of migrant stock from the D_{1j} function does not threaten to bias estimates of parameters of the migration function.

The remaining variable of the migration function is the origin and destination wage measurement. Initially the choice of data on wages will follow the main thrust of the migration literature, using average hourly earnings in manufacturing as the wage index. The difficulty with this index stems from its incomplete coverage of the labor force and job vacancies. Of course migration decisions should be based on real wages. Deflation of wages in labor market areas implies the use and

¹It might seem that lagged values of the migrant stock, functioning as an element of labor supply at the origin, would have a significant negative correlation with origin wages. However, Chapter IV:3 demonstrates that the direction of this relationship is ambiguous. John Harris has noted that migrant stock should vary directly with distance.

existence of cost of living indexes for metropolitan areas. These indexes are designed primarily to be time-series measurements of maintaining a particular standard of living for a narrowly defined family group in a given labor market.¹ The primary difficulty in applying such price indexes to the deflation of wages in the migration function is not their narrow focus on a family of four specific individuals but rather the impossibility of standardizing for the quality of those goods whose quality varies most across areas. Prices of manufactured goods, raw materials, and other transportable materials should vary among areas by little more than differential transport charges from points of production. The great potential for differences in prices among areas lies in housing services which comprise 25% of the average worker's budget. There is no mechanism or data base that would enable one to construct a quality index which would make possible the specification of prices of housing services of standard quality in metropolitan areas across the United States.² Thus present price or cost of living indexes for urban areas are inherintly unsuitable for cross-section analyses.

¹ The source of cost of living estimates for urban areas presently available is the City Worker's Family Budget series described in: Lamale, H.H. and M.S. Stotz, "The Interim City Worker's Family Budget," Monthly Labor Review, Vol. 83, (August, 1960), pp. 785-808.

² It might be possible to develop the quality index described here using hedonic regression techniques if sufficient data on housing price and physical characteristics were available.

The lack of effective cost of living indexes limits any attempt to estimate migration functions and evaluate the importance of the offer acceptance probability term. There is one assumption concerning the migration decision which removes cost of living terms from the migration function. If workers assume that prices at the destination are the same as those prevailing at the origin, the cost of living index appears in the numerator and denominator of V:4:1, and divides out of the final functional form. This may not be an unreasonable assumption because workers undoubtedly find information on destination prices as illusive as the Bureau of Labor Statistics.

Equation V:4:1 may be rewritten in terms of arguments for which data are available.

$$V:4:2) \quad M_{ij} = \left[\frac{E(w_{oj})}{E(w_{a1j})} - \frac{E(w_{a1j})}{E(w_{oj})} \right] (E_i E_j / E_T) S_i (a_j - a_i) D_{ij} [(a_j - a_i), -C_{ij}(r_{ij}, E(w_{oj}))]$$

where: $E(w_{oj})$ and $E(w_{a1j})$ = average hourly earnings in manufacturing at i and j.

E_i and E_j = employment at i and j.

$(a_j - a_i)$ = difference in temperature humidity index, wind chill factor, and number of clear days per year between i and j.

r_{ij} = distance between areas.

The basic relationship between the terms of the migration function is multiplicative. If V:4:2 is to be written in a form that can be made linear in its parameters, then the internal form of the S_i and D_{ij} functions must be multiplicative.

$$V:4:3) s_i = S_i(a_j - a_i) = s_o (a_j - a_i)^{s^*}$$

$$V:4:4) d_{ij} = D_{ij}(a_j - a_i, -C_{ij}(r_{ij}, E(w_{oj})) \\ = d_o (a_j - a_i)^{d_1} (r_{ij})^{d_2} (E(w_{oj}))^{d_3}$$

where: s_o , s^* , d_o , d_1 , d_2 , d_3 are all parameters

Substituting these expressions for S_i and D_{ij} into V:4:2 and adding parameters for offer acceptance probability and employment, gives an expression that is linear in its logarithms, which is shown in untransformed form below:

$$V:4:5) M_{ij} = b_o s_o d_o E(w_{oj})^{-\frac{1}{2} E(w_{aij})} b_1 (E_i E_j / E_T)^{b_2} (a_j - a_i)^{(s^* + d_1)} \\ (r_{ij})^{d_2} (E(w_{oj}))^{d_3}$$

The signs of all the constants and, in some cases the magnitudes, have been developed previously. Only the parameter which reflects the product of b_o , s_o , and d_o has not received explicit attention. Actually this term may be greater than or equal to zero.

There is a final difficulty with the difference in attractiveness terms, $(a_j - a_i)$. This term may be negative but that would leave the logarithmic transformation

The basic relationship between the terms of the migration function is multiplicative. If V:4:2 is to be written in a form that can be made linear in its parameters, then the internal form of the S_i and D_{ij} functions must be multiplicative.

$$V:4:3) \quad s_i = S_i(a_j - a_i) = s_0 (a_j - a_i)^{s_1}$$

$$V:4:4) \quad d_{ij} = D_{ij}[(a_j - a_i), -C_{ij}(r_{ij}, E(w_{oj}))] \\ = d_0 (a_j - a_i)^{d_1} (r_{ij})^{d_2} (E(w_{oj}))^{d_3}$$

where: $s_0, s_1, d_0, d_1, d_2, d_3$ = parameters

Substituting these expressions for S_i and D_{ij} into V:4:2 and adding parameters for offer acceptance probability and employment, gives an expression that is linear in its logarithms, which is shown in untransformed form below.

$$V:4:5) \quad M_{ij} = b_0 s_0 d_0 \left[\frac{E(w_{oj})}{E(w_{a1j})} \right]^{b_1} (E_i E_j / E_T)^{b_2} (a_j - a_i)^{s_1 + d_1} \\ (r_{ij})^{d_2} (E(w_{oj}))^{d_3}$$

The signs of all the constants and, in some cases the magnitudes, have been developed previously. Only the parameter which reflects the product of b_0, s_0 , and d_0 has not received explicit attention. Actually there is no reason to assume that this term differs significantly from zero.

There is a final difficulty with the difference in attractiveness terms, $(a_j - a_i)$. This term may be negative but that would leave the logarithmic transformation

undefined. To eliminate this problem, two dummy variables are introduced for each element of attractiveness. The first dummy takes the value unity when $(a_j - a_i)$ is negative and zero otherwise. The other dummy variable alternates between zero and unity in the opposite fashion. For each element of attractiveness two variables are then generated, each equal to the product of one of the dummy variables and the logarithm of the absolute value of the difference in attractiveness. Since none of the measures of attractiveness is the same at two locations, this procedure yields a function whose logarithms are all defined.

The final form of the equation V:4:5 that was estimated in logarithmic form is given below:

$$\begin{aligned} \text{V:4:6) } \log M_{ij} = & (b_0 s_0 d_0) + b_1 \log \left[\frac{E(w_{oj}) - \frac{1}{2} E(w_{aij})}{E(w_{aij}) E(w_{oj})} \right] + b_2 \log(E_i E_j / E_T) \\ & + (s_1 + d_1) X_1 \log(a_j - a_i) + (s_1 + d_1) X_2 \log(a_j - a_i) \\ & + d_2 \log(r_{ij}) + d_3 \log(E(w_{oj})) \end{aligned}$$

where: X_1 and X_2 are the dummy variables mentioned above

$E(w_{oj})$ and $E(w_{aij})$ are based on mean wage rates

In V:3 sources of data on migrants between urban areas were discussed. Other data on employment and average hourly earnings were taken from standard sources.¹ These variables

are constructed as averages of the five year period spanned in the migration data. Three elements of attractiveness were considered for each area: the temperature-humidity index during summer months; the wind-chill factor during winter months; and the number of clear days per year.¹ These indexes presumably reflect climatic and environmental attractiveness. Finally distance is measured in airline mileage between cities.

Table V:4:1 gives the results of ordinary least squares estimates of V:4:6, first without arguments due to the S_i and D_{ij} functions and then describes the fully elaborated form. The reason for estimating the simplified version of the equation is clear from observation of b_1 , the elasticity of migration with respect to the offer acceptance probability. The addition of variables reflecting attractiveness causes b_1 to take on reasonable values that are significant at the ten percent confidence level. This change appears to be due to an association between wages and attractiveness that is understandable on an a priori basis. As labor market areas move from positions of short-run disequilibrium toward long-run equilibria in which net migration is zero, there is a fundamental trade-off between wage rates and

¹There are certainly other elements of attractiveness which are not related to climatic or meteorological attributes of an area. But the attributes selected here are readily measured and presumably are recognized by migrants before they move. Other more esoteric elements of attractiveness related to unique cultural attributes or public facilities may not be apparent to potential migrants.

undefined. To eliminate this problem, two dummy variables are introduced. The first dummy takes the value unity when $(a_j - a_i)$ is negative and zero otherwise. The other dummy variable alternates between zero and unity in the opposite fashion. For each element of attractiveness two variables are then generated, each equal to the product of one of the dummy variables and the logarithm of the absolute value of the difference in attractiveness. This yields a function whose logarithms are all defined.

Table V:4:1 gives the results of ordinary least squares estimates of V:4:5 first without arguments due to the S_i and D_{ij} functions and then describes the fully elaborated form. The reason for estimating the simplified version of the equation is clear from observation of b_1 , the elasticity of migration with respect to the offer acceptance probability. The major change associated with additional variables added to the estimated equation is that b_1 takes on a reasonable value and is significant at the 10% level. This change appears to be due to an association between wages and attractiveness that is understandable on an a priori basis. As labor market areas move from positions of short-run disequilibrium toward long-run equilibria in which net migration is zero, there is a fundamental trade-off between wages and

TABLE V:4:1

U.S. Aggregate Migration Function - No Modifications

Parameter	Equation I	Equation II
$b_{o s d o}$	1.43 (1.01)	3.14 (1.63)
b_1	0.10 (0.55)	0.53 (1.63)
b_2	0.61 (7.24)	0.63 (7.22)
d_2		-0.30 (-2.13)
d_3		-2.60 (-1.34)
THI* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.02 (0.19) -0.24 (-2.02)
WCF* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.14 (1.34) 0.29 (2.75)
Days Clr.* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		-0.15 (-1.56) -0.03 (-0.35)
F Test (100 obs.)	31.3	8.8

Key... Attractiveness factors are as follows: THI is the temperature humidity index; WCF* is the wind chill factor; Days Clr.* is the average number of days clear per year. X_1 is a dummy variable indicating destination attractiveness is > origin attractiveness. X_2 is a dummy variable indicating destination attractiveness is < origin attractiveness.

attractiveness. The ratio of migration from i to j , M_{ij} , to that from j to i , M_{ji} , has wages and attractiveness as its only arguments.¹

$$V:4:7) \frac{M_{ij}}{M_{ji}} = \frac{(P_{aij})^{b_1} (a_j - a_i)^{s_1+d_1} (E(w_{oj}))^{d_3}}{(P_{aji})^{b_1} (a_i - a_j)^{s_1+d_1} (E(w_{oi}))^{d_3}}$$

where: P_{aij} and P_{aji} are offer acceptance probabilities defined in terms of relative wages.

Clearly one of the reasons that wage variables employed as arguments of migration functions have often had unusual signs or have not been significant is that these elements of attractiveness have been eliminated. Additional attention should definitely be paid to elements of attractiveness that affect migrants, both because workers are aware of them and because they are important elements of real income in an area.

An additional issue that complicates estimation of an aggregate migration function is the possibility of aggregation bias in the parameters of the model discussed in V:2. Two methods of dealing with this problem were developed in V:2: using dummy variables for each origin; and developing aggregating factors based on the age and education of workers

¹This is really an extension of conditions for an equilibrium among labor markets first developed in Chapter II:2. The results developed there reflect the standard long-run equilibrium condition that real income at all locations must be equal. Obviously the equilibrium condition in V:4:6 is found by letting (M_{ij}/M_{ji}) equal unity.

at the origin. The difficulty with extensive use of dummy variables is that such formulations ignore empirical information on the nature of the population at the origin and that dummies may be correlated with specific characteristics of the origin that have nothing to do with aggregation problems. Indeed this apparently was the case when a set of origin dummies were used to estimate equations following the form of V:4:6. The signs and significance of the coefficients of offer acceptance probability associated with each origin oscillated wildly.

Use of aggregating factors produced the improved results indicated in Table V:4:2. The offer acceptance probability term was multiplied by an aggregating factor identical to that developed in equation V:2:7. In each case the factor reflects the relative propensity of individuals at the origin to move. This relative propensity was calculated first in Table IV:2:1. The coefficient of this new adjusted aggregate offer acceptance probability variable presented in Table V:4:2 is significant at the 5% level. This compares favorably to the 10% confidence level applicable to the coefficient of unadjusted offer acceptance probability presented in Table V:4:1. Other parameter estimates differ little between

TABLE V:4:2

U.S. Aggregate Migration Function With Aggregating Factors

Parameter	Equation I	Equation II
$b_o s_o d_o$	1.43 (1.00)	2.89 (1.64)
b_1	0.08 (0.64)	0.37 (2.08)
b_2	0.61 (7.33)	0.64 (7.40)
d_2		-0.33 (-2.36)
d_3		-1.91 (-1.34)
THI* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.05 (0.42) -0.27 (-2.24)
WCF* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.09 (0.84) 0.28 (2.64)
Days Clr.* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		-0.18 (-1.75) -0.04 (-0.43)
F Test (100 obs.)	21.2	9.1

Key... Attractiveness factors are as follows: THI is the temperature humidity index; WCF* is the wind chill factor; Days Clr.* is the average number of days clear per year. X_1 is a dummy variable indicating the destination attractiveness is > origin attractiveness. X_2 is a dummy variable indicating destination attractiveness is < origin attractiveness.

equation II in Table V:4:1 and equation IV in Table V:4:2.

There is an additional dimension to the aggregation problem that must be considered. In V:2 the possibility of aggregation bias in the variables as well as the parameters of an aggregate migration function was developed. In this case available data sources and a priori information are not sufficient to provide schemes for consistent aggregation of the arguments of an aggregate migration function. Thus the use of average hourly earnings in the results presented earlier may not lead to consistent aggregation. There is one mechanism for evaluating the possible impact of aggregation bias in the estimates given in Tables V:4:1 and V:4:2. This involves estimating a migration equation based on an alternate wage index. In this case the index is based on a random sample of wages in specific occupations. The wage index is simply set equal to the mean of these specific wages and not weighted by the fraction of the total labor force in that occupation as is the case with average earnings in manufacturing. Aggregation problems arising in the wage variables are based on the notion that the labor market is very compartmentalized with little possibility of movement between occupations or industries. If the labor market is sufficiently heterogeneous so that

aggregation bias is a significant problem, the use of an unweighted wage index should produce results that differ from those based on average hourly earnings in manufacturing.

Table V:4:3 presents estimates of the same equations reported in Tables V:4:1 and V:4:2 with the unweighted wage index substituted for average hourly earnings. There is remarkably little difference between the estimates in Table V:4:3 and those based on weighted wage indexes. Indeed the estimate of b_1 , the elasticity of migration with respect to offer acceptance probability, in equation IV is 0.37 in Table V:4:2 with a weighted wage index, and 0.41 in Table V:4:3 where the unweighted index is used. Thus aggregation bias in the wage variables appears to be of limited importance.¹

The aggregate migration equation V:4:5 was also estimated using data on migrants from the United Kingdom. Unfortunately no data on attractiveness at various locations was available and the earnings index was income per capita rather than wages. However data on migrant flows is available for two time periods, 1959-1960 and 1965-1966.²

¹ Other unweighted wage indexes were also tested with similar results.

² The nature and sources of migration data were discussed in V:3.

TABLE V:4:3

U.S. Migration Function Based On Unweighted Wages

Parameter	Equation I	Equation II
b_{oso}	1.68 (1.20)	2.29 (1.73)
b_1	0.58 (1.68)	0.34 (1.16)
b_2	0.61 (7.41)	0.52 (5.09)
d_2		-0.38 (-2.68)
d_3		5.60 (1.85)
THI* $\begin{cases} x_1(s_1+d_1) \\ x_2(s_1+d_1) \end{cases}$		0.07 (0.64) -0.19 (-1.64)
WCF* $\begin{cases} x_1(s_1+d_1) \\ x_2(s_1+d_1) \end{cases}$		0.15 (1.37) 0.24 (2.26)
Days Clr.* $\begin{cases} x_1(s_1+d_1) \\ x_2(s_1+d_1) \end{cases}$		-0.15 (-1.54) -0.02 (-0.22)
F Statistic	22.4	9.24

TABLE V:4:3 (Continued)

U.S. Migration Function Using Unweighted Wages And
Aggregating Factors

Parameters	Equation I	Equation II
$b_{o s d_o}$	1.54 (1.10)	0.62 (1.04)
b_1	0.28 (1.40)	0.41 (2.07)
b_2	0.63 (7.50)	0.62 (6.91)
d_2		-0.36 (-2.58)
d_3		0.40 (1.28)
THI* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.08 (0.66) -0.24 (-2.18)
WCF* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		0.10 (0.95) 0.25 (2.43)
Days Clr.* $\begin{cases} X_1(s_1+d_1) \\ X_2(s_1+d_1) \end{cases}$		-0.16 (-1.68) -0.02 (-0.26)
F Statistic	18.6	10.3

Key...Attractiveness factors are as follows: THI is the temperature humidity index; WCF* is the wind chill factor; Days Clr.* is the average number of days clear per year. X_1 is a dummy variable indicating destination attractiveness is $>$ origin attractiveness. X_2 is a dummy variable indicating destination attractiveness is $<$ origin attractiveness.

The availability of a time series of cross-section observations of the dependent variable makes the use of dummy variables for each origin reflect differences in propensity to migrate. As was suggested in V:2, a set of dummy variables was defined, one for each of six origins for which migration data was available. Each variable takes on the value unity when migrants emanate from a particular origin and zero otherwise. A series of six offer acceptance probability variables is then generated by multiplying each dummy by the logarithm of offer acceptance probability calculated as in V:4:5 using income per capita instead of wage data.

The estimated elasticity of migration with respect to offer acceptance probability in Table V:4:4 is somewhat higher than that found for the United States. Equation I, which does not include a time dummy, (zero for 1960 and unity for 1966), or the logarithm of destination wages, yields a mean estimate of 1.22 for b_1 . Equation II gives a mean of 1.67 for b_1 , but the logarithm of destination wages, or income per capita which is used in lieu of wage data, is inexplicably negative and significant.

Given the limitations imposed by data scarcity, the discrepancies in estimates of b_1 between models based on

TABLE V.4:4

U.K. Aggregate Migration Function With Separate
Estimate Of Wage Elasticity Of Migration
For Each Of Six Different Cities*

	AreaI	Area2	Area3	Area4	Area5	Area6		Time
	b_1	b_1	b_1	b_1	b_1	b_1	b_2	Dummy**
Eq.#I	2.20	1.46	0.75	1.32	1.18	0.42	0.45	
"t"	(5.70)	(3.10)	(2.05)	(3.66)	(4.67)	(1.97)	(31.61)	
Eq.#II	1.87	1.76	1.50	1.46	1.84	1.70	1.23	-9.32 3.37
"t"	(1.58)	(1.27)	(1.27)	(1.30)	(2.24)	(2.43)	(13.3)	(-2.66)(2.69)

* The urban areas of the U.K. are as follows: area 1 is Tyneside; area 2 is West Riding; area 3 is South Lancaster; area 4 is Merseyside; area 6 is West Midlands; and area 6 is Greater London.

** The time dummy is zero in 1960/61 and unity in 1965/66.

*** The F test for equation I was 30.1 and for equation II it was 56.6. Both are significant at the one percent level. There were 60 observations

data from the United States and those using figures from the United kingdom are not large. However, more thorough validation and evaluation of aggregate migration functions must wait upon the availability of more extensive data on migrants between metropolitan areas.

Chapter VI

SUMMARY OF THE JOB-SEARCH MODEL OF MIGRATION

The task of this thesis, the derivation, specification, and estimation of a job-search model of migration, has been completed. The model developed here represents a significant extension of the economics of information, and the body of microeconomic theory. This chapter will first review these innovations. Next implications for other results in the literature on migration will be discussed. Finally applications and suggestions for future research will be reviewed.

VI:1) Contribution To Microeconomic Theory

The attempt has been made, where possible, to follow the reasoning and notation common in the job-search literature. For example, much of the analysis is based on the important concept of an acceptance wage. But the acceptance wage used in the migration model is based on a combination of wages, search costs, and attractiveness. The ordinary job-search models of individual labor markets do not consider problems of relative attractiveness since this is constant within a market area.

Similarly the concept of an offer-acceptance probability is not unknown in the job-search literature.¹ Indeed within a local labor market the acceptance wage determines the probability that a wage chosen from the prevailing distribution will be accepted. This is not the case with the model of migration. Offer-acceptance probability varies among destinations and is determined by a joint probability density function of origin and destination wages. Thus the analogy between job-search models and the migration model developed here is based more on notation than substance.

One characteristic that is common to the migration model and ordinary job-search models is consistency with assumptions of microeconomic theory. Workers are attempting to maximize the expected value of their real income. But they face a distribution of earning opportunities at each alternative location, and positive costs of searching each opportunity. If wages in each area were deterministic, the migration model would yield the same sort of result as classic microeconomic theory: offer-acceptance probability would be 1 or 0 depending on the magnitude of origin and destination wages and migration would follow to high wage areas where search was concentrated. Similarly if search costs go to zero, the migration model

¹ Much of the notation and elements of the offer-acceptance probability concept used in this thesis is based on: Holt, Charles, "How To Alter The Relationship Between Inflation And Unemployment In The U.S.," (The Urban Institute), 1970.

would yield the same results as classic microeconomic theory since every area with wages higher than the origin would be searched and the acceptance wage would be equal to the maximum wage in any area.¹ Indeed zero search cost is equivalent to the notion of perfect information in microeconomic theory since information is ubiquitous.

Useful additions needed to incorporate job-search models of migration into a formal system of regional labor market interactions would include a theory of firm behavior. This is necessary to generate the distribution of offered wages in each area as a function of search costs and labor turnover costs. Completion of this element of analysis would enable one to model the simultaneity between migration flows and the demand for labor discussed in Chapter IV.

Empirical results from the estimated migration equations indicate that migration is consistent with ordinary market clearing processes. The coefficient of offer-acceptance probability, b_1 , was positive and significant in all equations estimated in Chapter V. Since offer-acceptance

¹ If wages are deterministic, then dw_{0i}^M/dn is 0 for searches beyond one and by III:5:2 workers accept any offer above present wages. Similarly, if search costs are 0, then the $\partial C_{1j}/\partial n$ term in III:5:2 is 0 and as long as there is any increase in wages associated with further search workers will continue searching jobs - i.e. no wage below the maximum offered wage available will be accepted.

probability varies directly with destination wages and inversely with origin wages, the implied labor flows go from relatively low wage to high wage areas.

VI:2) Comparison With Other Migration Functions

The job-search model of migration developed here is more firmly grounded in microeconomic theory than approaches based on "gravity" models reviewed in Chapter II. The actual migration finally estimated in Chapter IV required that an origin and destination wage distribution be assumed. Given the assumed distributions, a unique functional form suitable for estimation can be derived. However, the functional form estimated here must be viewed as a special case of the general migration function developed in Chapter III.

There is some similarity between the functional form of the job-search migration equation estimated (equation V:4:6) and other migration models in the literature. It is common to find migration equation estimates that involve the logarithm of the ratio of destination and origin wages, or separate logarithms of destination and origin wages. As stated in Chapter II, the result of this approach has been to find only the logarithm of destination wages significantly

related to migration flows. The logarithm of wage ratio variables and of origin wages is not found significant. This has led to speculation that wages have a "pull" but not a "push" effect on potential migrants. As an exercise the migration data used in this study both from the U.S. and U.K. were tested in migration equations involving all the functional forms reviewed above: origin-destination wage ratios; and origin and destination wage terms considered separately. The results of other migration studies were generally confirmed with wage ratios never proving significant and individual wage terms generally insignificant and/or possessing the wrong sign.

The job-search model of migration incorporates a relative wage term in the offer-acceptance probability. Estimates of the migration function show offer-acceptance probability coefficients consistently significant with signs indicating migration increases with destination wages and decreases with origin wages. This means that there is no paradox of "push" vs "pull" effects, but rather a basic symmetry of wage effects, consistent with microeconomic theory.

The difference in empirical results associated with substitution of the logarithm of offer-acceptance probability for the logarithm of the wage ratio arises from a difference

in the functional forms involved. Wage ratio terms with destination wages in the numerator increase at a constant rate with destination wages and decrease at a decreasing rate with origin wages. Offer-acceptance probability terms based on the uniform wage distribution assumed in Chapter V are shown below along with first and second derivatives.

$$\text{VI:2:1) } P_{aij} = (w_{oj}/w_{aij}) - \frac{1}{2}(w_{aij}/w_{oj})$$

$$\begin{aligned} \text{VI:2:2) } dp_{aij}/dw_{oj} &= (1/w_{aij}) + w_{aij}/w_{oj}^2; \\ dp_{aij}/dw_{aij} &= -(w_{oj}/w_{aij}^2) - \frac{1}{2}(1/w_{oj}) \end{aligned}$$

$$\begin{aligned} \text{VI:2:3) } d^2P_{aij}/dw_{oj}^2 &= -2(w_{aij}/w_{oj}^3) \\ d^2P_{aij}/dw_{aij}^2 &= 2(w_{oj}/w_{aij}^2) \end{aligned}$$

Thus offer-acceptance probability increases at a decreasing rate with destination wages and decreases at a decreasing rate with origin wages. Thus offer-acceptance probabilities derived from the job-search model vary differently with wages than the simple wage ratio terms used in other migration functions. This difference in functional forms makes a great deal of difference in the empirical results obtained from least squares estimates of the parameters. Since other migration functions are not based on micro-models of worker behavior, it is not possible to account for the failure of wages to be significant in other functional forms on the basis of a priori arguments.

While the job-search model of migration represents an important departure from previous analytical approaches to migration, the job-search is consistent with much of the other literature reviewed. Indeed the approach taken in this thesis was suggested by an extensive examination of survey research on migrants. Workers consistently report a migration decision based on limited information with target or acceptance wage goals.

Similarly the job-search approach is consistent with descriptive studies of historic migration movements. Such classical results as the tendency of flows in one direction to generate reverse flows are explained by the tendency of individuals to search in their former home area and the notion of an offer-acceptance probability based on origin wages. Thus workers may accept a position in what appears to be a lower wage area provided that the offered wage is above the relevant acceptance wage. This kind of consistency with survey literature and descriptive studies perhaps provides a stronger confirmation of job-search approaches than any other piece of empirical evidence.

APPENDIX AI

As was established in the introduction, migration equations often play a most important role in models of regional and urban growth. Undoubtedly the most controversial of these models is Urban Dynamics.¹ This appendix will show that the behavior of the urban dynamics model is dominated by its migration equations and that a more reasonable specification of these equations alters the behavior of the model significantly.

The urban dynamics model is a continuous simulation of strictly recursive difference equations connecting 20 state variables. These variables completely characterize the city at any time and are chosen to reflect the major components of an urban environment: housing; land, whose total area is fixed; employment or industry; and population. The model has not been fitted to a particular urban area. It is designed to fit an area large enough to contain a labor and housing market but constrained in size by features of accessibility, topography, and/or political fiat (e.g. a greenbelt).

Although none of the variables in Urban Dynamics is operationally defined, they have an intuitive appeal to anyone familiar with the popular literature on "the urban problem." Population is divided into manager, labor, and underemployed

¹Forrester, Jay W., Urban Dynamics, (Cambridge, Massachusetts: M.I.T. Press), 1969.

groups, presumably based on socio-economic status. Three grades of housing are distinguished: premium; worker; and slum housing, reflecting the housing budget of the three population groups. The three kinds of industry - new enterprise, mature enterprise, and declining industry - employ different mixes of the three population types with total labor per enterprise declining with age. Since output per worker and land area per worker is generally larger in newer plants, thus empirical evidence suggests that declining industry might have more workers per unit land area. But simulation experiments have shown that the parameters governing labor input per type of enterprise have little effect on model behavior. Indeed this insensitivity characterizes the response of the urban dynamics model to changes in most individual parameters.

The urban dynamics model reaches an apparently steady state for most reasonable initial values of the state variables. This equilibrium is due in large part to the fixed land area and the discouraging effect which increasing gross densities have on all forms of activity within the city.

The steady state of the urban dynamics model is characterized by stable values for population and its three components. Such population stability implies balance between the forces tending to change population levels;

in-migration; out-migration; upward social mobility; downward social mobility; and net natural increase. Each demographic group sires only offspring of its own kind and marriage between classes is forbidden. Such assumptions violate "the American dream" and perhaps reality as well. Social mobility depends on job opportunities in different labor markets, and on public expenditures, presumably on retraining and education.

The migration equations of Urban Dynamics are formulated so that people move in response to the condition of the city relative to an unchanging environment.

"For any class of person, conditions in the area must be approximately equal in attractiveness to conditions elsewhere. As an example, conditions in a city for people in the lowest economic class will not be substantially better or worse than the conditions in other parts of the country from which there is free mobility."¹

Thus the proper indicator of success for the city is its ability to achieve a given mix of attractiveness factors relative to the unchanging environment. Attractiveness consists of many factors.

"Attractiveness is a multidimensional concept and includes factors such as legal restrictions, prejudice, racial and ethnic groupings, and anything else that influences a person to move. Some of these are represented explicitly in the urban model. All others are combined into the mobility coefficients on the basis that they can be treated as constants and are not involved as dynamic variables in the modes of urban change here explored."²

Components of relative attractive attractiveness are imbedded

¹Forrester, Jay, ibid., pg. 117.

²Forrester, Jay, ibid., pg. 118.

in the constants of the migration function and in the few state variables generated endogenously by the model.

There are separate in and out-migration equations for each population group. The migration equations for the underemployed are most important and have the following form:¹

$$AI:1) \quad UA = (U+L) (UAN) (AMMP)$$

$$AI:2) \quad UD = U (UDN) (UDM)$$

where: UA = underemployed arrivals per unit time

UD = underemployed departures per unit time

U = number of underemployed in the city

L = number of laborers (workers) in the city

UAN = "normal" underemployed arrivals rate = .05

AMMP = relative attractiveness for migration

UDN = "normal" underemployed departure rate = .02

UDM = relative unattractiveness for migration

The constant factors mentioned above are embodied in the constants UAN and UDN. The (U+L) and U terms, in equations AI:1 and AI:2 respectively, are justified as scaling factors. In the steady state there is an inverse relationship between relative attractiveness, AMMP, and unattractiveness, UDM.

$$AI:3) \quad AMMP = AMM = (UDM)^{-1}$$

where: AMM = attractiveness for migration multiplier
(relative attractiveness of the city)

¹ Forrester, Jay, ibid., pg. 135.

If there were no natural increase or social mobility, the steady state would be characterized by an equality of arrivals and departures.

$$\text{AI:4)} \quad UA = (U+L) .05 (\text{AMM}) = UD = U .02 (\text{AMM})^{-1}$$

Solving for AMM, we find that it must be less than one.

$$\text{AI:5)} \quad \text{AMM} = [.02 U / .05 (U+L)]^{\frac{1}{2}} < 1$$

In the case of both laborers and managers the scaling factors for in and out-migration are identical. Thus when similar expressions to AI,5 are derived for attractiveness to laborers (LAM) and to managers (MAM), the scaling factors cancel out and exact numerical values can be obtained for relative attractiveness.

$$\text{AI:6)} \quad \text{LAM} = (\text{LDN } L / \text{LAN } L)^{\frac{1}{2}} = (.02 / .03)^{\frac{1}{2}} = 0.815$$

$$\text{AI:7)} \quad \text{MAM} = (\text{MDN } M / \text{MAN } M)^{\frac{1}{2}} = (.02 / .03)^{\frac{1}{2}} = 0.815$$

Where: LAM = relative attractiveness for migration to laborers

LDN = "normal" labor departure rate = .02

LAN = "normal" labor arrival rate = .03

MAM = relative attractiveness for migration to managers

MDN = "normal" manager departure rate = .02

MAN = "normal" manager arrival rate = .03

In all cases relative attractiveness, as indicated by AMM, LAM, and MAM, in the city is below that in the environment. The addition of net natural increase, modeled as a proportional increase in each population type, only lowers the relative

attractiveness of the city further, since even more people must be induced to emigrate each year. As compared to zero net migration in the case analyzed above, with net population increase steady state migration must produce net outflows equal to the population increase.

The effect of population growth and social mobility on relative attractiveness of the city can be analyzed by writing the equations for total change in each population group.

$$(\text{Change}) = (\text{In-migration}) - (\text{Out-migration}) + (\text{Increase}) + \frac{\text{Social}}{\text{Mobility}}$$

$$\text{AI:8) } DU = .05(U+L)(AMM) - .02(AMM)^{-1} + (UB) + (LTU) - (UTL)$$

$$\text{AI:9) } DL = .03 L (LAM) - .02(LAM)^{-1} + (LB) - (LTM) - (LTU) + (UTL)$$

$$\text{AI:10) } DM = .03 M (MAM) - .02(MAM)^{-1} + (MB) + (LTM)$$

where: DU = net change in underemployed population per year

DL = net change in labor population per year

DM = net change in manager population per year

UB, LB, MB = net natural increase per year of underemployed, laborers, and managers respectively

UTL = mobility of underemployed to labor category

LTU = mobility of laborers to underemployed category

LTM = mobility of laborers to manager category.

The steady state is characterized by stable levels of all population groups, $DM = DL = DU = DP = 0$. Adding equations AI:8, AI:9, and AI:10, gives an expression for population change, DP , involving only attractiveness and natural

increase.

$$\text{AI:11) } DP = .05(U+L)(AMM) - .02(AMM)^{-1} + UB + .03L(LAM) - .02L(LAM)^{-1} \\ + LB + .03M(MAM) - .02M(MAM)^{-1} + MB = 0$$

In equation AI:11, DP varies directly with all three attractiveness multipliers, AMM, LAM, and MAM, and with the three natural increase variables, UB, LB, and MB. Thus there is a fundamental tradeoff between all six of these variables. Any rise in rates of natural increase lowers attractiveness as was asserted above. Similarly improving attractiveness to one group will result in lower attractiveness to other groups if natural increase is constant.¹

Inherent in the nature of the attractiveness functions, AMM, LAM, and MAM, is the immutability of their parameters which reflect individual tastes and the constant environment. While the policy-maker has control over the parameters that affect the steady-state values of the arguments of the attractiveness function, he cannot control the total attractiveness associated with a given menu of arguments of the attractiveness function. Temporary increases (decreases) in attractiveness to a particular group are quickly wiped out by increases (decreases) in the relevant population types that reduce the attractiveness of the area.

¹ Formalizing this argument, we have found that $(dAMM/dMAM)_{DP=0}$ and $(dAMM/dLAM)_{DP=0}$ and $(dLAM/dMAM)_{DP=0}$ are all negative.

The inability to change total attractiveness is illustrated admirably by Table AI:1 which shows the population and attractiveness of the city in its "stagnant" steady state and Professor Forrester's favorite urban renewal policy: slum housing demolition and new enterprise construction.

TABLE AI:1

Attractiveness Under "Stagnation" And "Revival"

"Stagnation"	Variable Name	"Urban Revival"
0.449	AMM	0.428
0.625	LAM	0.611
0.307	MAM	0.297
377,300	U	335,900
392,600	L	600,000
71.100	M	108.700

The revived city has more population living at uniformly lower levels of average attractiveness. All three attractiveness multipliers are lower because with the rise in population annual net population increase is larger. The city must be less attractive in order to induce net out migration equal to natural increase. Equation AI:11 shown the inverse relationship between attractiveness and population increase. The revival policy adjusts components of attractiveness, trading off housing for employment and tax base. Because these three important variables are linked in the attractiveness functions, it is impossible to find the classic match of

selective and efficient policy instruments to manipulate housing, taxes, public services, and jobs toward individual targets.

Policy-making in such an environment of constant attractiveness implies imposition of a particular set of values. Given that all classes of residents are going to be fairly unhappy with the city, is there any reason to make them unhappy over one component of attractiveness than another? Clearly this depends on the components. After a long series of substitutions into the attractiveness functions, it is possible to arrive at rather straightforward expressions for attractiveness.¹

$$\text{AI:12)} \quad \text{AMM} = f(\text{U}, \text{L}, \text{UH}, \text{LJ}, \text{UJ}, \text{TPCR})$$

$$\text{AI:13)} \quad \text{LAM} = g(\text{U}, \text{L}, \text{WH}, \text{LJ}, \text{TR})$$

$$\text{AI:14)} \quad \text{MAM} = h(\text{M}, \text{L}, \text{U}, \text{PH}, \text{MJ}, \text{TR})$$

where: UH, WH, and PH = indexes of the availability of
(and prices of) underemployed, labor, and
managerial housing respectively

UJ, LJ, and MJ = indexes of the availability of
underemployed, laborer, and managerial
jobs respectively

TPCR = city tax per capita ratio

TR = tax ratio of city to outside environment.

¹Because the model is so complex and functions are tabular rather than analytic, the simple process of substituting out intermediate variables is very messy and might take up to ten pages of exposition. However the intellectual process of successive substitution is trivial and the final results are presented in AI:12 to AI:14.

Because the functional relationships in the urban dynamics model are expressed in terms of actual graphs, or table functions, it is difficult or impossible to find an exact analytic expression for equations AI:12 - AI:14. However, the signs of the derivatives of AMM, LAM, MAM with respect to the housing, job, and tax variables can be determined fairly unambiguously. The key to evaluating these derivatives is the fact that virtually all the table functions in the urban dynamics model are monotonic increasing or decreasing. Since the model always operates well within the limits of the table functions, the signs of derivatives are easily read from the slope of the graphs. The signs of the derivatives are displayed in Table AI:2 below.

TABLE AI:2

Signs Of Derivatives Of Attractiveness Functions

Function	Variable	Underemployed		Laborer		Manager	
	Taxes	Housing	Jobs	Housing	Jobs	Housing	Jobs
AMM	-	+	+	0	+	0	0
LAM	-	0	0	+	+	0	0
MAM	-	0	0	0	0	+	+

The signs of these derivatives illustrate the policy-making problem discussed earlier. The values of the attractiveness functions are constrained to be less than one. Signs of the derivatives indicate that, for the underemployed, housing

availability can only be increased at the expense of job availability or tax increases. Similar results hold for other population groups.

Whether Urban Dynamics is viewed as an accurate representation of city growth processes or not, the most important result of this inquiry is the importance of the migration equations to the urban dynamics model, and particularly to policy conclusions based on the model. Indeed the migration equations contain information on the fundamental long-run tradeoffs facing the city. The variables determining attractiveness of an area for migration reflect desires of the population for the quality of urban life. Such desires are the proper concern of public officials. This is the key to the importance of migration functions to any policy-oriented model of urban development.

GLOSSARY OF NOTATION

This thesis contains a great deal of notation that may not be familiar to the reader. The rather complex expressions in Chapters III and V are particularly difficult to read. Hopefully this glossary of notation will aid in interpreting notation which is not particularly intuitive.

- a_j ... value of attractiveness at area j in terms of dollars per unit time
- A_k ... weighting factor reflecting relative propensity of demographic group k to migrate
- $b_0 s_0 d_0$... constant term in the migration equation estimated
- b_1 ... coefficient of offer-acceptance probability in the migration equation estimated
- b_2 ... coefficient of the product of origin and destination area employment divided by total employment in the migration equation estimated
- C_j ... total cost to a firm at j of having x_j unfilled vacancies
- c_{ij} ... cost per opportunity searched at j by residents of area i - NB: $c_{ij} = C_{ij}(n_j, w_i)$
- c_{ij}^* ... total cost of all search effort at j by residents of area i - NB: $c_{ij}^* = C_{ij}^*(n_j, w_i)$
- d_2 ... coefficient of distance in the migration function
- d_3 ... coefficient of destination wages in the migration function estimated
- d_{ij} ... fraction of total search effort by workers at i directed to opportunities in area j .

- E_i ... total employment in area i
 E_i^k ... fraction of total employment in area i consisting of members of demographic group k
 G_i ... index of attractiveness at j measured in terms of units of the element of attractiveness itself rather than dollar units
 h ... efficiency units per migrant
 H ... labor input in efficiency units
 I ... maximum wage offered in area i
 J ... maximum wage offered in area j
 K ... total units of homogeneous capital
 K_j ... moving cost from origin to area j
 M_{ij} ... migrants from area i to area j
 \bar{M}_{ji} ... migrant stock from area j currently residing in area i
 n ... total searches made at all destinations
 N_i ... total population in area i
 n_j ... number of opportunities searched in area j
 N_i^k ... number of individuals of demographic type k in area i
 P ... price of homogeneous output
 p_a ... difference between offered and acceptance wages (same as z_{ij})
 P_i ... potential migrants in area i
 p_{ij} ... probability that acceptance wage at i is less than offered wage at j
 p_{aij} ... offer-acceptance of individuals at i for offers from area j
 Q ... total output of homogeneous product

- r ... rate of return on capital
 r_{ij} ... distance from area i to j also used for recruiting costs facing firms
 S ... total sales of homogeneous product
 s_i ... average number of searches per potential migrant per time period
 S_{ij} ... number of searches per time period per potential migrant from i in area j
 T ... expected duration of employment in a job being sought
 V_j ... total vacancies in area j
 w ... any particular value of wages (also W)
 w_{ai} ... index of acceptance wage at i
 w_{aij} .. acceptance wage of workers at i for offers from j
 w_i ... current wages of residents of area i
 w_{oj} ... offered wages of firms at j
 w_{oj}^M ... expected value of maximum offered wage found at j
 NB: $w_{oj}^M = W_{oj}^M(n_j)$
 X_1 ... dummy variable equal to one when origin attractiveness greater than destination attractiveness, zero otherwise
 X_2 ... dummy variable equal to one when origin attractiveness less than destination attractiveness, zero otherwise
 x_i ... applicants recruited from area i
 Y_i ... income of workers in area i
 z_{ij} ... difference between offered and acceptance wages (in the appendix to Chapter II, fraction of population at i that moves to area j)